

UNCLASSIFIED

AD 296 345

*Reproduced
by the*

ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

13-2-4



3-80-62-10

**BERYLLIUM: A SURVEY
OF THE LITERATURE
JANUARY - MARCH 1962:
AN ANNOTATED BIBLIOGRAPHY**

REC'D 15 1962
ASTIA
B

**SPECIAL BIBLIOGRAPHY
SB-62-22**

OCTOBER 1962

296 345
CATALOGED BY ASTIA 296345

AD TWO.

3-80-62-10

**BERYLLIUM: A SURVEY
OF THE LITERATURE
JANUARY - MARCH 1962:
AN ANNOTATED BIBLIOGRAPHY**

Compiled by
JACK B. GOLDMANN

SPECIAL BIBLIOGRAPHY
SB-62-22

OCTOBER 1962

Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

ABSTRACT

The following annotated bibliography covers publications released during the first quarter of 1962. Citations are arranged alphabetically by author under broad subject headings of Alloys; Analysis; Applications; Compounds; Corrosion; Fabrication Techniques; Joining; Mineralogy; Oxides; Powder Metallurgy and Casting; Processing; Properties; and Miscellaneous. Reference to the use of beryllium in fuels, nuclear reactor applications, effects of radiation, and Cu-Be alloys have been omitted.

Availability notices and procurement instructions following the citations are direct quotations of such instructions appearing in the source material announcing that report. The compiler is well aware that many of these agencies' names, addresses and office codes will have changed; however, no attempt has been made to update each of these notices individually.

In citing classified reports, (SECRET TITLE) or (CONFIDENTIAL TITLE) as appropriate, has been used when that classification of the title was indicated on the report. (UNVERIFIED TITLE) has been used when the report was not available to the compiler and it was impossible to verify the report's title and the title's security level.

Classification of classified reports is indicated by abbreviation in upper right top line of bibliographic entry. The classification of the report is given in full, e.g., SECRET REPORT, at the conclusion of the bibliographic data for that report entry.

This selective bibliography has been prepared in response to a specific request and is confined to the limits of that request. No claim is made that this is an exhaustive or critical compilation. The inclusion of any reference to material is not to be construed as an endorsement of the information contained in that material.

BERYLLIUM

ALLOYS

1. Adamovich, L. P. and Yutsis, B. V.
Photometric determination of small quantities of
beryllium in aluminum alloys. UKRAINSKI
KHIMICHESKI ZHURNAL v. 22, no. 4, p. 523-526.
1956. (In Ukrainian); (English translation: 1961.
MT Trans-187, M. de O. Tollemache. The Old
Rectory. Lewknor, Oxon, England)
2. Beaver, W. W.
BERRYLLIUM-BASE ALLOYS. Institute of
Metals. Conference on Metallurgy of Beryllium,
London 1961. Preprint No. 69. 1961. 16 p.

Beryllium-base alloys of potential application appear to be of the duplex "ductile-matrix" variety, i.e., beryllium with aluminum, silicon, silver, or tin in binary or ternary combinations, possibly some of the few solid-solution types, and undoubtedly those within the many dispersed-phase-hardening alloys available. The characteristics of each group are described. The presence of ceramic and, particularly, of intermetallic compounds in dispersed-phase-hardening alloys substantially increases the temperature of the ductile--brittle transition, and such alloys are suitable not only for elevated-temperature application, but also for low-temperature uses requiring high YS and dimensional stability. Alloys consisting mainly of intermetallic compounds of beryllium and transition elements provide light, high-strength materials melting up to 4000° F (2200° C) and retaining much of the desirable thermal, mechanical and nuclear characteristics of beryllium at temperature well above its melting point. Such materials, particularly those containing tantalum, zirconium and niobium are evaluated as to design characteristics and use.

3. Firsanova, L. A. et al
The obtainment of beryllium-aluminum-copper
alloys produced through the reduction of vaporous
beryllium chloride (and) the obtainment of mag-
nesium-base zirconium ligature alloys by reduction

3. (cont'd)

of fused salts. VYSSHIKH UCHEBNIKH

ZAVEDENII. ISVESTIYA. TSVETNAYA

METALLURGIYA No. 1, p. 59-66, 91-98.

(In Russian); (English translation: OTS/SLA

61-19551. 13 Oct 1960. 23p.)

Beryllium-Aluminum-Copper Alloys: The reduction of vaporous beryllium chloride permits the use of beryllium chloride, which is contaminated by beryllium oxide or other non-volatile mixtures. The use of fluxes is eliminated for lowering the vapor tension of beryllium chloride. The maximum solubility of beryllium into aluminum (1000° to 1100°C) occurs with no great loss of beryllium chloride due to volatility.....

4.

Fuchs, F. O.

CAST MAGNESIUM ALLOYS CONTAINING

SMALL AMOUNTS OF BERYLLIUM. German

Patent 1, 018, 628. 30 Oct 1957. (In German)

Grain-coarsening and strength-diminishing effect of the ignition-impeding beryllium addition (0.001-0.005%) can be avoided if the fine-grain-promoting treatment of the melt is carried out before beryllium is added. The amount of grain-size-decreasing additive required by 0.001% beryllium is 0.2% hexachloroethane or 1% FeCl_3 .

5.

Fuchs, F. O.

CAST MAGNESIUM ALLOYS CONTAINING

BERYLLIUM. German Patent 1, 027, 410.

3 April 1958. (In German)

Addition to German Patent 1, 019, 093. The beryllium in magnesium alloys causes slight decrease in strength of the alloys. This is avoided by addition of 0.1-0.5% copper and 0.1-0.5% silicon.

6. Hindle, E. D. and Slattery, G. F.
A METALLOGRAPHIC SURVEY OF SOME
DILUTE BERYLLIUM ALLOYS. Institute of
Metals. Conference on Metallurgy of Beryllium,
London, 1961. Preprint No. 58. 1961. 8p.

Beryllium alloys containing 0.1 and 1.0 wt.-% each of calcium, aluminum, silicon, titanium, chromium, tin, zirconium and iron were prepared by arc- or induction-melting. The alloys were examined by metallographic and x-ray methods with a limited application of the electron-microprobe x-ray analyzer. The techniques of metallographic preparation are described and information is presented on the nature and mode of occurrence of the alloy phases. The results are discussed with respect to the literature available on the various alloy systems. The results are applied to the examination of beryllium fabricated from powder, and impurity phases arising from carbon, calcium, silicon and aluminum were identified.

7. Jordan, C. B.
INVESTIGATION OF THE EFFECT OF ULTRA
RAPID QUENCHING ON METALLIC SYSTEMS,
INCLUDING BERYLLIUM ALLOYS. Electro-
Optical Systems, Inc., Pasadena, Calif.
Progress report no. 2, 1 June-30 Sept 1961.
EOS report 1650-4M-2. 15 Oct 1961. 13p.
(Contract AF 33(616)8011. Project 1(8-7351)).
ASTIA AD-264 988.

Progress is reported of an investigation of the effect of ultra-rapid quenching on certain alloys of beryllium. The experimental techniques previously developed were applied with only minor modifications to alloys of the systems Be-O, Be-Al, Be-Si, Be-Sc, Be-Ni, Be-Cu, and Be-Zn. No changes in phase appear to have been induced by ultra-rapid quenching in most of the alloys tested, although a shift of lattice parameter has been observed in several. Definite phase changes appear to have been induced in one Be-Cu alloy and in two Be-Ni alloys, but these results are subject to further confirmation.

8. Tyapkin, Yu. D., Bagaryatskii, Yu. A. and Gavrilova, A.V.
Study of the changes in crystal structure of
nickel-beryllium alloy at an early aging stage.

SOVIET PHYSICS - CRYSTALLOGRAPHY

v. 6, no. 4, p. 448-455. January-February 1962.

The atomic structural mechanism of the aging of nickel-beryllium alloy after quenching and annealing at 425° and 550° C is studied by means of x-ray photographs of single crystals obtained in soft and hard characteristic radiations. The changes in crystal structure are compared with the hardness of the alloy after different aging conditions.

9. United Kingdom Atomic Energy Authority,
London, England. BERYLLIUM ALLOYS.
British Patent 821,424. 7 Oct 1959.

Alloys of beryllium and one or more of the metals Pu, Ac, Am, Cm, Th, U, and Ce are produced. Thus heating 142 mg. PuF_2 and 65 mg. beryllium in a vacuum at 1150° for one hour gave 154 mg. of a Pu-Be alloy containing 70% Pu, free of halide slag. Similar alloys were made with fluorides of U or Ac instead of PuF_3 . The beryllium was used as a reducing and an alloying element.

ANALYSIS

10. Adamovich, L. P. and Kravchenko, T. U.
Salicylic acid as a reagent for the spectro-
photometric determination of beryllium.
ZAVODSKAYA LABORATORIYA v. 23,
p. 416-420. 1957. (In Russian); (English
trans. by H. J. de Bruin. AAEC/Trans-9. 8p.)

The reaction between beryllium salts and salicylic acid was studied by the spectrophotometric method in the ultra violet portion of the spectrum. The optimum pH value for this process was found to be 9.0 to 9.5. Two independent methods showed that beryllium and salicylic acid form a compound in the ratio 1:2. The instability

10. (cont'd)

constant was determined for a complex of the formula $(\text{Be OH Sal}_2)^{3-}$ namely $(4.9 \pm 0.6) \times 10^{-18}$. The stability of the complex and the availability of the reagents makes the reaction investigated a suitable one for analytical applications.

11.

Aidarkin, B. C. et al

A method of determining beryllium in ores by

means of photoneutrons. AKADEMIA NAUK

SSSR. RADIEVOGO INSTITUTA IMENI V. G.

KHLOPINA. TRUDY v. 5, no. 2, p. 89-93.

1957. (In Russian) (English trans. AEC-tr-4498.

TRANSACTIONS OF THE V. G. KHLOPINA

RADIUM INSTITUTE, v. 5, no. 2, p. 99-105.

1957)

The method consists of the irradiation of the ore with gamma rays and measuring the intensity of the induced radioactivity which is proportional to the beryllium content, and comparison of the measurements with a standard. To obtain accurate results, it is necessary to compare equal weights of sample and standard, while at the same time ensuring equal dimensions of the irradiated layer, to ensure that the densities do not differ significantly, and to assure that the respective beryllium contents do not differ by more than a factor of 5 to 10. Tests indicate that for increasing beryllium contents above 1% the error decreases approximately as the square root of the concentration: at 0.45% content the error was 13%, at 5% content the error was 3%, and at 50% content the error will be ~ 1%.

12.

Appala Raju, N. and Neelakantum, K.

Azo dyes as analytical reagents for aluminum

and beryllium. CURRENT SCIENCE v. 29,

no. 2, p. 52-53. 1960.

12. (cont'd)

Aluminum and beryllium salts were treated with aqueous alcoholic solutions of certain azo dyes giving characteristically colored lakes. Sixteen dyes having (a) OH ortho to the azo group (Magneson type); (b) OH ortho to the COOH group; or (c) both characteristics (a) and (b) (Diamond Black F type) gave similar tests for aluminum and beryllium. Phenylazo-2-naphthol gave a yellow lake with beryllium. 4-HOC₆H₄N:Ph and 4-H₂NC₆H₄N:Ph gave no lakes.

13.

Berezin, I. A. and Aleksandrovich, K. V.

Determination of sulphur, chlorine and fluorine
in beryllium oxide by a spectrographic method.

AHURNAL ANALITICHESKOI KHIMII v. 16,

p. 613-616. 1961 (In Russian)

A method was developed for the spectrographic determination of sulphur, chlorine and fluoroine in beryllium oxide by means of a hollow cathode. The method permits the determination of 0.001% of chlorine: 0.003% of sulphur, and 0.005% of fluorine in 50 mg samples. The mean relative error is $\pm 15-20\%$.

14.

Bleshinskiĭ, S. V. and Abramova, V. G.

Determination of beryllium with sodium fluoride.

AKADEMIIA NAUK KIRGIZ SSR. INSTITUTA

KHIMII. TRUDY, no. 6, p. 133-138. 1955.

(In Russian)

A new procedure is described for the detection of beryllium in beryl with sodium fluoride.

15.

Cotterill, P., Goosey, R. E. and Martin, A. J.

AN EVALUATION OF THE HYDROGEN CONTENT
OF COMMERCIALLY PURE BERYLLIUM AND ITS
EFFECT UPON THE DUCTILE-TO-BRITTLE
TRANSITION TEMPERATURE. Gt. Brit. Atomic

15. (cont'd)

Weapons Research Establishment, Aldermaston,

Berkshire, England. Oct 1961, 7p.

The paper describes the use of a vacuum-fusion technique for the determination of the hydrogen content of beryllium. It is concluded that the solubility of hydrogen in solid beryllium is negligibly low, the hydrogen evolved during analysis being directly attributable to a surface absorption effect. The use of an axially aligned tensile-testing technique has shown that the room-temperature brittleness of beryllium is due to the orthodox ductile-brittle transition effect occurring in the range 100-200° C; this being uninfluenced by any attempt at hydrogenation.

16.

Dressel, W. M. and Ritchey, R. A.

FIELD TEST FOR BERYLLIUM. U.S. Bureau

of Mines Information Circular no. 7946. 1960, 5p.

A small portion of the pulverized rock is fused with a $\text{Na}_2\text{CO}_3\text{NaOH}$ flux in a wire loop. After fused mass is dissolved in water, and a few drops of quinizarin are added, the solution is viewed under ultraviolet light. A pink-to-orange fluorescence reveals the presence of beryllium in a sample which contains as little as 0.013% beryllium.

17.

Franzen, J. and Hintenberger, H.

Multi-atomic molecular ions in high frequency

sparks between electrodes from the elements Be,

C, Mg, Al, Ti, Fe, and Cu. ZEITSCHRIFT FUER

NATURFORSCHUNG v. 16a, p. 535-539, June

1961. (In German)

With the exception of boron, in all the elements investigated multi-atomic molecular ions were detected in a high frequency spark. In addition to carbon and the other elements of the fourth group of the periodic table, aluminum and especially beryllium are strongly inclined to the formation of multi-atomic molecular complexes. In aluminum the ion Al_7 occurs with preferable frequency. In beryllium not only Be atoms occur alone, but also Be atoms combined with oxygen atoms in multi-atomic complexes, of which the $\text{Be}_{n+1}\text{O}_n$ complex is distinguished by preferable frequency.

18. Hiser, R. A., Donaldson, H. M. and Schwenzfeier, C. W.

A rapid analytical method for the determination
of beryllium in air samples. AMERICAN INDUS-
TRIAL HYGIENE ASSOCIATION. JOURNAL v. 22,
p. 280-285, Aug 1961.

A method is described which consists of sample collection on Whatman #41 filter paper, ashing of the sample, and subsequent conversion to beryllium fluoride. The formation of a lake with p-nitrophenylazoarcinol, and comparison of the Klett reading with a standard curve gives beryllium content. (For optimum results, samples should contain 5 to 45 micrograms of beryllium.) Interfering heavy metals are chelated with Dow's Versene "T". Copper and zinc are complexed with dyanide. The method is recommended only for air samples collected on Whatman #41 paper or equivalent.

19. Korenman, I. M. and Grishin, I. A.

Fluorescent reactions of beryllium and aluminum.
KHIMIA I KHIMICHESKAIA TEKHNLOGIIA v. 1,
n. 2, p. 383-388, 1958. (In Russian)

The ability of a great number of anthraquinone dyes (e.g. Fast Mordant Blue B, Eriochrome Red B, Chrome Blue-Black R, etc.) to give fluorescent reactions with aluminum and beryllium salts was studied. Several reagents were found giving highly sensitive fluorescent reactions with beryllium salts (detectable limit $1:10^7$) and aluminum salts (detectable limit $1:2 \times 10^7$).

20. Lindsay, H. M., Scott, V. D. and Moore, A.

Selective decoration of fine structural effects
in beryllium. JOURNAL OF THE LESS COMMON
METALS v. 3, n. 5, p. 407-411, 1961.

A new chemical method to reveal sub-microscopic structural effects in beryllium, such as iron-rich precipitates developed during ageing, has been developed. The method involves an ion-exchange reaction in which copper decorates localized regions in the metal and it is simply carried out by immersing the metallographic surface in an orthophosphoric acid solution containing dissolved copper. The metallographic features have been correlated using optical microscopy, electron microscopy and electron probe microanalysis. Some indication of the wider application to other metal systems is given.

21. Mackay, K. J., Sawkill, J. and Schwarzenberger, D. R.

DIVERGENT-BEAM X-RAY MICROSCOPY OF

BERYLLIUM. Tube Investments Research

Laboratories, Hinxton Hall, Cambridge, England.

Oct 1961. 3p.

The x-ray point-projection microscope is particularly suited to the study of beryllium, where research is required on the properties of single crystals, and on the mechanism of deformation in polycrystalline material. With this instrument, a microradiograph, formed by variations in the thickness and composition of the specimen, is recorded at the same time as the divergent-beam diffraction pattern. The information obtained from these combined records has included the determination of crystals, and some aspects of deformation, fracture, and recrystallization in polycrystalline specimens.

22. Maekawa, S. and Yoneyama, Y.

Studies on the determination of trace elements

in iron and steels. VI. Spectrophotometric

determination of beryllium in iron and steel

using acetyl acetate extraction method.

BUNSEKI KAGAKU v. 10, p. 732-736.

July 1961. (In Japanese)

The extraction of beryllium-acetylacetone complex with chloroform and the spectrophotometric determination of beryllium was applied for the iron and steel analysis. 0.25 g of sample is decomposed in 10 ml of perchloric acid, and when chromium content exceeds 3%, most of it is evaporated as chromyl chloride. The solution is diluted exactly to 250 ml and an aliquot (2 to 10 ml) is taken. 5 ml of citric acid solution (20 %) and 10 ml of theylenediamine-tetraacetic acid (5 %) are added to mask iron and other elements. 1.0 ml of acetylacetone aqueous solution (5%) and 10 ml of sodium chloride (20%) are added, and pH is adjusted to 7.0 ~ 7.5 by use of 1N sodium hydroxide. Beryllium complex is extracted with 10 ml of chloroform. The organic phase is backwashed with 50 ml of 0.1N sodium hydroxide to remove free acetylacetone, and the backwashing is done again. The light absorption is measured at 295 mμ by comparison with chloroform. Where the aluminum content exceeds 5%, beryllium is read a little higher, as a bit of aluminum probably forms an acetylacetone and is extracted with chloroform.

23. Mazurenko, E. A.
Chromatographic separation of titanium, zirconium,
beryllium, aluminum and iron. PRATSI ODES'KOGO
DERZHAVNOGO UNIVERSITETU IMENI I. I.
MECHNIKOVA v. 149, ZBIRNIK STUDENTS'-
KIKH ROBIT, no. 5, p. 133-136. 1959.
(In Ukrainian)

Quantitative separation of beryllium was achieved by ion-exchange chromatography with cationic resin KU-1. Conditions of separation and results of tests are given.

24. Meyer, R. A., Austerman, S. B. and Swarthout, D. G.
ISOTOPIC OXYGEN RATIO IN BeO BY MASS
SPECTROMETRY. Atomics International, Div. of
North American Aviation, Inc., Canoga Park,
Calif. Report NAA-SR-6426. 30 Oct 1961. 12p.
(Contract AT (11-1)-GEN-8)

An analytical method was developed for the determination of O^{18} in 1 to 5 mg samples of finely-ground BeO containing 0.2 to 2.0% of O^{18} . A vacuum fusion apparatus using platinum flux contained in a graphite crucible at 2000°C was CO^{18}/CO^{16} ratio with a modified consolidated 21-620 mass spectrometer. The standard deviation of the method was ± 0.002 with the O^{18} concentration was approximately 0.2%. Each single sample of a series required an average vacuum fusion time of 30 minutes and mass spectrometer time of 10 minutes.

25. Sawkill, J. and Schwarzenberger, D. R.
Observations on imperfections and deformation in beryllium by divergent beam x-ray photography. ACTA CRYSTALLOGRAPHICA
v. 13, no. 12, p. 1060. Dec 1960.

25. (cont'd)

When a highly divergent beam of x-rays from a point source is transmitted through a crystalline specimen two distinct types of contrast may be recorded: (1) the diffraction pattern of excess and deficiency conics which is normally used to study the perfection and lattice parameters of good single crystals, and (2) the microradiography which is formed by absorption contrast arising from variations in thickness and composition of the specimen. There are advantages in considering these two types of information together, particularly for metallurgical specimens of suitable grain size and thickness where both diffraction and absorption contrast are recorded simultaneously on a photographic plate placed in the path of the transmitted beam. These advantages are discussed, and demonstrated by a series of divergent x-ray beam photographs taken on a point projection x-ray microscope (1) at intervals along a zone refined single crystal rod of beryllium, giving information about the variation in perfection and subgrain structure, the variation in lattice parameter, and the distribution of impurities along the rod; (2) at different stages during the deformation and recrystallization of polycrystalline beryllium, revealing the formation and extension of cracks and the changing perfection of the grains.

26. Shcherbov, D. P. and Plotnikova, R. N.

Fluorometric determination of submicrogram

quantities of beryllium in ore. ZAVODSKAYA

LABORATORIIA v. 27, p. 1058-1062. 1961.

(In Russian)

The fluorometric determination of 0.05 to 1.0 γ of BeO without preliminary separation from ore samples is described. Characteristics of fluorescence reactions for determining beryllium are tabulated.

27. Straumanis, M. E. and Mathis, D. L.

Beryllium crystals disintegrate; fragmenta-

tion of beryllium anode during electrolysis.

CHEMICAL AND ENGINEERING NEWS v. 39,

no. 38, p. 50. 18 Sept 1961.

27. (cont'd)

Beryllium metal tends to disintegrate when it dissolves (as in hydrochloric acid. If this effect is ignored during anodic dissolution, the metal appears to go into a solution in the +1 state. Too much metal is lost for the amount of current passed. In many of these solutions, a black precipitate forms during dissolution. This precipitate consists of beryllium hydroxide and beryllium metal. Formerly, it was assumed that this mixture arose by disproportionation of Be^{+1} . However, beryllium metal cannot be produced from aqueous solutions, anodically or otherwise. Photomicrographs of the dissolving metal and the metal particles found in the black sludge were studied. Twinned crystals were found in the sludge from anodes of cast beryllium that were originally present in the metal. However, many fewer twinned crystals were found when a powder metallurgy material was used. This shows that the metal crystal needles come from the original piece of metal and are not formed by some secondary process. Ions of uncommon valence may be formed in anodic processes. But care must be taken to show that disintegration of the metal while anodic current is flowing isn't disregarded.

28. Sulcek, Z., Michal, J. and Dolezal, J.

Separation of beryllium on silical gel. CZECHO-

SLOVAK CHEMICAL COMMUNICATIONS.

COLLECTION v. 25, p. 283-284. 1960.

(In German)

Separation of beryllium from Fe(III) or Al is carried out by passing the beryllium solution in a buffer through a SiO_2 column and washing the beryllium out with HCl (diluted 1:1). Beryllium is then determined by means of morin. In the presence of other elements, EDTA is used for masking (in a 100% excess).

29. Suvorovskaya, N. A., Voskresenskaya, M. N. and

Mel'nikova, T. A.

The determination of beryllium in beryllium-

bearing minerals and ores. NAUCHNYE SOOBSHCHNYE

INSTITUT GORNOGO DELA AKADEMIIA NAUK SSSR.

v. 6, p. 63-66. 1960. (In Russian)

29. (cont'd)

0.25 g of sample is fused with 3 g of Na_2CO_3 at 1150° for 3.5 hours, the melt is leached with HCl (1:1), SiO_2 is separated and measured by the usual procedure. When an insoluble residue appears it is fused with $\text{K}_2\text{S}_2\text{O}_7$, and the melt is leached with water and added to the main solution. On an aliquot portion of the solution the combined hydroxides of beryllium, aluminum and iron are precipitated and calcium and magnesium are determined by difference from the total hydroxides or the hydroxides are fused with Na_2CO_3 , the melt is leached with water and $\text{Al}(\text{OH})_3$ is precipitated with NH_4OH . Beryllium is measured by one of three methods. (1) Beryllium is precipitated together with the total hydroxides which are dissolved in HCl and beryllium is separated by means of NaOH and Na_2S . The determination is completed calorimetrically with beryllon 11-IREA; (2) beryllium is precipitated with CO_2 -free NH_4OH . Precipitation is made in the cold, the precipitate is filtered off, dissolved in 0.25N. NaOH solution. The determination is completed calorimetrically with beryllon 11-IREA or morin; (3) the solution containing iron is neutralized with NH_4OH , which is added until a turbidity appears, the precipitate is heated, 5 ml. of $\text{Ti}(\text{SO}_4)_2$ solution (5 mg $\text{TiO}_2/\text{ml.}$) are run in and 10 ml. of 10% $(\text{NH}_4)_2\text{HPO}_4$ solution after which NH_4OH is added until methyl red shows an alkaline reaction and the whole is left over night. The precipitate is filtered off, dissolved in 11 ml. of 1.25N. NaOH solution. An aliquot portion is taken for beryllium determination. The first method shows the greatest error.

30.

Taketatsu, T.

Chemical analysis by the use of EDTA (Parts V

and VI) NIPPON KAGAKU ZASSHI v. 79, p. 586-594.

1958. (English trans. by D. Jackson. NP-tr-797.

21p.

The use of an ion exchange resin and EDTA for separation of beryllium from other metal ions was investigated. Beryllium did not elute with the use of a 11.5×0.7 cm volume of Amberlite IR-112 resin and 1 liter of 0.5% EDTA solution ($\text{pH} = 3.7$) and it could thus easily be separated from Cu, Zn, Cd, Pb, Co, Ni, and Th, which elute at 100 ml, or from Mn, Ce, and U which completely elute at 300 to 500 ml. Beryllium can also be separated from iron by this method but not from Al, Ti, or Cr. The separation of beryllium and aluminum was studied further and the effects of the amount of EDTA added and the temperatures were examined. At a pH of 4.3 to 3.5 at temperatures below 20°C when a solution containing EDTA, Al, and Be were passed through a resin column, the beryllium was absorbed, but the aluminum passed through completely.

31. Umland, F., Hoffman, W. and Meckenstock, K. U.
Distribution of metal-8-hydroxyquinolates between
water and organic solvents, VI. 8-Quinolinol
complexes of beryllium, strontium, and barium.
ZEITSCHRIFT FUER ANALITISCHE CHEMIE
v. 173, p. 211-227. 1960. (In German)

The following compounds of 8-quinolinol (HOx) were extracted from H_2O into $CHCl_3$: $MgOx_2$, $CaOx_2$, and $BeOx_3$; H_2BaOx_4 and $HSrOx_3$; RNH_3MeOx_3 where Me = Be, Mg, Ca, or Sr and $(RNH_3)MeOx_4$ where Me = Sr and Ba. Correlations of previous methods are discussed.

32. United Kingdom Atomic Energy Authority. Engineering Group, Windscale, Cumberland, England and United Kingdom Atomic Energy Authority.
Production Group, Windscale, Sellafield, England.
ANALYTICAL METHOD FOR THE DETERMINATION OF BERYLLIUM COLLECTED ON FILTER PAPER USING A DIRECT READING SPECTROMETER. PG-Report-182. 1961. 8p.

A method was developed for the determination of beryllium collected on a filter paper through which a known volume of air was drawn or which was used for a smear test. The sample was ignited and the residue digested with Hcl and HF acids. The solution was then analyzed by the graphite spark technique using a three-channel integrating photometer. The precision of the method was -30% at 0.001 μg Be and the concentration range was 0.0002 to 0.02 μg per pair of electrodes.

33.

Wallace, C. G.

THE VOLUMETRIC DETERMINATION OF

BERYLLIUM IN BERYL ORE. United Kingdom

Atomic Authority, Research Group, Chemistry

Division, Woolwich Outstation, England. Report

AERE-AM-29. May 1959. 6p.

The ore is decomposed by fusion with excess alkali metal carbonate and the silica removed with hydrofluoric acid. Alumina is removed by a second fusion with alkali carbonate and the remaining oxides are ignited. Beryllium oxide is selectively reacted with alkali metal fluoride and determined by titration of the liberated alkali. The procedure is particularly suitable for high-grade ores where oxides of Ca, Mg, Fe, Ti, and Zn are not present together in amount exceeding the beryllium oxide content. Scandium oxide causes appreciable interference and should not be present in excess of 3 % of the beryllium oxide content. At the level of 10% beryllium oxide the error is not likely to exceed 0.1% and the results have a coefficient of variation of 1%.

APPLICATIONS

34.

Barber, A. H.

Materials of construction for chemical plant -

new metals. CPE/CHEMICAL AND PROCESS

ENGINEERING AND ATOMIC WORLD. v. 42,

p. 451 - 458. Oct 1961.

Physical and mechanical properties, fabrication, application and economic considerations of Be, Zr, Nb and Ta.

35.

Bennett, W. D.

RECENT BERYLLIUM RESEARCH IN CANADA.

Canadian Westinghouse Co., Ltd., Hamilton,

Ontario. Oct 1961. 6p.

35. (cont'd)

A program of evaluating commercially available grades of beryllium rod for reactor applications has produced results which are of interest in diagnosing the cause of room-temperature brittleness in beryllium. Axial tensile tests indicate that beryllium changes from a ductile to a brittle metal over a relatively narrow temperature range and also exhibits a double-yield-point phenomenon under certain conditions of testing. An interpretation of results in terms of impurity - dislocation interaction explains the change from fibrous to cleavage-type fractures with changes in temperature and strain rate, predicting that the ductile range could be extended to room temperature by a combination of grain refinement, increased purity, and a reduction in strain rate. Metallographic studies confirm that the drop in ductility at higher temperatures is associated with the onset of intergranular fracture and demonstrate the occurrence of three types of fracture: cleavage below the transition, intergranular at the higher temperatures, and a mixture of cleavage and fibrous in the intermediate range. There is a significant difference between the mechanical properties of metal water-quenched after 24 hours at 900°C. and metal slow-cooled.

36.

Korringa, J. et al

USE OF BERYL CRYSTALS FOR LONG-WAVE-

LENGTH X-RAY SPECTROSCOPY. Ohio State

University. Research Foundation, Columbus.

Technical Report No. 7. June 1957. 35p.

(Contract N60nr-225(21)) PB 135359.

Beryl crystals used in the two-crystal spectrometer had changed during the past five years resulting in a decrease in their percent reflection. This change, when combined with the increase in the width, reflects similar changes in the spectral window of the spectrometer and a corresponding decrease in resolving power.

37.

Morozumi, S. and Shiroyanagi, I.

Influence of beryllium on the properties of Mg-1%

Al alloy. NAGOYA KOGYO GIKYU SHIKENSHO

HOKOKU v. 9, p. 271-274, 1960. (In Japanese)

37. (cont'd)

The work hardening and the recrystallization temperature of Mg-1% Al alloy are not influenced much by the addition of 0.015% beryllium. The mechanical properties of the alloy, owing to the grain growth promoted by beryllium, are lowered. However, the protective property against oxidation is improved.

38.

Perlmutter, I.

METALLURGICAL CONSIDERATIONS IN THE
APPLICATION OF BERYLLIUM TO AIRBORNE
STRUCTURES. Institute of Metals. Conference
on Metallurgy of Beryllium, London, 1961. Pre-
print no. 67. 1961. 17p.

The potential of beryllium as aircraft structural material is assessed on the basis of physical and mechanical properties. Comparison is made with other materials in the light of structural design criteria. A hypothetical example of a re-entry vehicle, using beryllium for primary structure, is described. The low ductility of beryllium is analysed from the metallurgical point of view, and the current status of this problem with respect to purity and anisotropy is reviewed. Typical applications of beryllium are described, and the joining of beryllium is discussed. It is concluded that significant gains in air- and space-craft performance can be attained by the application of beryllium sheet to airborne structures.

COMPOUNDS

39.

Agarwal, R. P. and Mehrotra, R. C.

2-hydroxy-3-naphthoic acid derivatives of beryl-

lium. JOURNAL OF THE LESS COMMON

METALS v. 3, no. 5, p. 398-406. 1961

Potentiometric, conductometric and preparative studies of beryllium 2-hydroxy-3-naphthoate systems indicate the formation of two complexes; the 1:1 complex predominates at pH of about 5.5 and the 1:2 complex in the ionic form at pH 8-9. In aqueous medium the 1:2 complex is precipitated first by the addition of potassium salt of the acid to a beryllium sulphate solution, which then changes into the 1:1 complex by the addition of one mole of alkali. In 50% alcoholic medium in which complexes have been calculated by Bjerrum's method. For comparison, stability constants for

39. (cont'd)

salicylate and sulpho-salicylate complexes were also determined under identical conditions. Stability constants k were found to be: $\log k_1 = 11.98$, $\log k_2 = 7.92$; $\log k_1 = 12.45$, $\log k_2 = 8.50$; $\log k_1 = 11.52$, $\log k_2 = 8.90$, respectively for 2-hydrox-3-napthoate, salicylate and sulphosalicylate complexes. Dissociation constants of the acids were determined in 50% alcohol using a hydrogen electrode. New compounds: $\text{BeC}_{11}\text{H}_6\text{O}_3 \cdot 2 \text{H}_2\text{O}$, $\text{H}_2\text{Be} (\text{C}_{11}\text{H}_6\text{O}_3)_2$ were isolated.

40. Bhattacharya, A. K. and Rao, G. S.

Formation of beryllium o-cresotate chelate.

JOURNAL OF SCIENTIFIC AND INDUSTRIAL

RESEARCH. (India) v. 18B, p. 351. 1959.

Chelation in the hydroxy monocarboxylic acids, either aliphatic or aromatic, occurs through the donation of a lone pair of electrons from the double bond oxygen of the carboxylic group only, rather than through the donation of a lone pair of electrons from the oxygen of the hydroxyl as reported by Varma and Mehrotra. This view is supported by the earlier work of Hantzsch on the salicylic acid chelates of Fe^{+++} . The greater chelation activity of a salicylate or a cresotate over the aliphatic monocarboxylates is due to acidic and labile nature of the hydrogen in the phenolic hydroxyl group which can be easily replaced by metal ions.

41. Bosik, I. I., Vorob'eva, O.I. and Novoselova, A. V.

The Li_2SO_4 - BeSO_4 - H_2O system at 25°. RUSSIAN

JOURNAL OF INORGANIC CHEMISTRY v. 5, no. 5.,

p. 556-558. May 1960.

The Li_2SO_4 - BeSO_4 - H_2O system has been investigated at 0° and 25° by measuring solubilities and specific gravities. At these temperatures $\text{BeSO}_4 \cdot 4\text{H}_2\text{O}$ and $\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ are the solid phases; binary salts are not formed. It has been found that lithium sulphate and beryllium sulphate reduce the solubility of one another. A saturated solution contains 14.05 wt. % Li_2SO_4 and 17.72 wt. % BeSO_4 at 0°, and 13.30 wt. % Li_2SO_4 and 21.46 wt. % BeSO_4 at 25°.

42. Bosik, I. I., Vorob'eva, O. I. and Novoselova, A. V.

Solubility in the Li_2SO_4 - BeSO_4 - H_2O system at 75° .

RUSSIAN JOURNAL OF INORGANIC CHEMISTRY

v. 5, no. 5, p. 564-565. May 1960.

The solubility isotherm has been determined in the Li_2SO_4 - H_2O system at 75° . It was found that the solid phase of the system contains $\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ and $\text{BeSO}_4 \cdot 4\text{H}_2\text{O}$; the formation of double salts was not observed.

43. Bruin, H. J. de and Temple, R. B.

THE FORMATION CONSTANTS OF THE BERYLLIUM

THENOYLTRIFLUOROACETONATES. Australia.

Atomic Energy Commission Research Establishment,

Lucas Heights, New South Wales. Report AAEC/E-76.

Sept 1961. 11p.

The formation constants of the mono- and bis-thenoyltrifluoroacetone complexes of beryllium are measured by a solvent extraction method. The values found are $\beta_1 = 3.40 \times 10^5$ and $\beta_2 = 1.21 \times 10^{11}$, in a medium of ionic strength 0.1, at a temperature of $25^\circ \pm 0.1^\circ$.

44. Funck, W.

Metal-ligand oscillations in organic beryllium

complexes. ZEITSCHRIFT FÜR PHYSIKALISCHE

CHEMIE v. 23, p. 297-299. 1960. (In German)

While investigations were made on metal-O valency oscillations, beryllium acetylacetone ($\text{Be}(\text{C}_5\text{H}_7\text{O}_2)_2$) were studied. The valency force and interaction constants are given and discussed.

45. Ganopolsky, V. I., Kolenkova, M. A. and Liner, A. I.

Process of producing basic beryllium carbonate.

VYSSHIKH UCHEBNIYE ZAVEDENII. TSVETNAYA

METALLY. IZVESTIYA v. 3, no. 3, p. 94 - 104.

1961. (In Russian)

A stable complex in two stages $\text{BeSO}_4 + (\text{NH}_4)_2\text{CO}_3 + \text{H}_2\text{O} = \text{Be}(\text{OH})_2 + (\text{NH}_4)_2\text{SO}_4 + \text{CO}_2$; $\text{Be}(\text{OH})_2 + 2(\text{NH}_4)_2\text{CO} = \text{NH}_4\text{BeCO}_2 + 2\text{NH}_4\text{OH}$ is formed by direct blending of BeSO_4 solution with crystalline $(\text{NH}_4)_2\text{CO}_3$. Basic BeCO_3 , a coarse-grained precipitate, is easily separated from the mother liquor.

46. Gough, A. R. S. and Bennett, E. W.

BERYLLIUM FLUORIDE. United Kingdom Atomic

Energy Authority, London, England. British

Patent, 833,808. 27 April 1960.

Thermal decomposition of $(\text{NH}_4)_2\text{BeF}_4$ results in beryllium fluoride. The latter is added to the molten BeF_2 , which is maintained in the liquid state at $850 - 950^\circ$, by passage of an electric current. Data show that BeF_2 has a negative coefficient of resistance. A graphite vessel with graphite electrodes is used.

47. Grigor'ev, A. I. and Semenenko, K. N.

The compound of beryllium oxyacetate with methyl-

amine. ZHURNAL NEORGANICHESKOI KHIMII

v. 3, p. 2806 - 2807. 1958. (In Russian)

The compound $\text{Be}_4\text{O}(\text{OAc})_6 \cdot 4\text{MeNH}_2$ crystallizes in a triclinic lattice with $a=8.34 \text{ \AA}$, $b=10.20$, and $c=9.44$, $\alpha=58^\circ$, $\beta=55^\circ$ and $\gamma=60^\circ$. The compound decomposes slowly above room temperature and loses MeNH_2 at $150 - 200^\circ$.

48. Grigor'ev, A. I. and Novoselova, A. V.
The reaction of basic beryllium formate and
propionate with ammonia. RUSSIAN JOURNAL
OF INORGANIC CHEMISTRY v. 4, no. 11,
p. 1218. Nov 1959.

The reaction of $\text{Be}_4\text{O}(\text{C}_2\text{H}_5\text{COO})_6$ with NH_3 yields the compound $\text{Be}_4\text{O}(\text{EtCO}_2)_6 \cdot 5\text{NH}_3$ and is analogous to the reaction of the oxyacetate. The reaction of $\text{Be}_4\text{O}(\text{HCO}_2)_6$ is different, apparently leading to the decomposition of the oxy salt.

49. Gurevich, V. M. and Zheludev, I. S.
Anomalies of electric conductivity in the region
of phase transformation and anisotropy of electric
conductivity of triglycinefluoroberyllate single
crystals. KRISTALLOGRAFIYA v. 6, p. 778-779.
1961. (In Russian)

50. Gurevich, V. M. and Zheludev, I. S.
Anomalous anisotropic electrical conductivity of
triglycine fluoroberyllate near the phase transition
point. SOVIET PHYSICS-CRYSTALLOGRAPHY
v. 6, no. 5, p. 624-625. March-April 1962.

51. Hamner, R. L. and Harris, L. A.
THE CALCINATION IN AIR OF BERYLLIUM
OXALATE TRIHYDRATE TO BERYLLIUM OXIDE.
Oak Ridge National Laboratory, Tenn. Report
ORNL-3183. 19 Oct 1961. 16p. (Contract
W-7405-eng-26)

Variations in sinterability of high-purity BeO powders obtained by calcining $\text{BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$ led to an investigation of the phase changes occurring during the calcination process. Studies were made under continuous and equilibrium heating conditions, using differential thermal analysis, thermogravimetric measurement, and room- and high-temperature x-ray analysis. Beryllium oxalate trihydrate decomposed to $\text{BeC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ when heated in air at 50°C , given sufficient time. A liquid phase was observed during decomposition to $\text{BeC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ under rapid heating conditions between 80 and 150°C ; this effect was not observed under "equilibrium" heating conditions at 100°C or below. The monohydrate was observed to decompose between 225 and 250°C . Complete decomposition to BeO was accomplished at 275°C and might occur as low as 250°C . No stable intermediate compounds except $\text{BeC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ were indicated during the calcination process.

52. Hyde, K.R., O'Connor, D.J. and Wait, E.
Preparation of beryllium fluoride from beryllia.
JOURNAL OF INORGANIC AND NUCLEAR
CHEMISTRY. v. 6, no. 1, p. 14-18. 1958.

The preparation of beryllium fluoride from two samples of beryllium oxide (calcined at 500° and $\approx 400^\circ\text{C}$) by treatment with anhydrous HF was studied in relation to temperature and time of reaction. The optimum temperature is about 220°C , and the amount converted, which may be as high as 98.4%, does not increase appreciably after one hour. X-ray analysis has given no evidence of solid solution formation between fluoride and unreacted beryllium oxide.

53. Isupova, E. N. and Keler, E. K.
Reactions in the BeO-SiO₂ system. RUSSIAN
JOURNAL OF INORGANIC CHEMISTRY v. 5, no. 5,
p. 542-544. May 1960

It has been confirmed that one compound only, beryllium orthosilicate, corresponding to the mineral phenacite, is formed in the BeO-SiO₂ system. Beryllium orthosilicate is not formed in the temperature range 1000°-1600° when mineralising additives are absent. Up to 1400° silicates are not formed in the BeO-SiO₂ system; i.e., the possibility of compounds stable only at high temperatures, and not detectable in the examination of the products at room temperature, has been excluded. 2BeO.SiO₂ is formed at 1350° and above in the presence of the mineralisers ZnO, MnO₂, Li₂CO₃, and Fe₂O₃. A phase chemical analysis of reaction products in the BeO-SiO₂ system has been developed. Conditions for the synthesis of beryllium orthosilicate have been studied in relation to temperature, duration of firing, grinding between firing, and addition of mineralizing agents. Beryllium orthosilicate is obtained in an 85% yield at 1350° with 2% of any of the above additives. Raising the temperature to 1500° allows the firing time to be reduced because the orthosilicate is then formed more quickly.

54. Keler, E. K. and Isupova, E. N.
Solid phases in the BeO-TiO₂ system. RUSSIAN
JOURNAL OF INORGANIC CHEMISTRY v. 5, no. 2,
p. 206-208. Feb 1960.

Regardless of the initial components, whether oxides or hydroxides, and of the presence of impurities in the mixtures, only the lines of the initial components have been observed on x-ray photographs of 1:1, 2:1, and 3:1 stoichiometric BeO-TiO₂ mixtures fired at 450°-1750°. Microscopic examination of the fired products in both ordinary and ultra-violet light disclosed the presence of only two phases. Thermograms, likewise, did not give indication of the formation of compounds. It has been concluded that compounds are not formed in the BeO-TiO₂ system.

55. Khandamirova, N. E. et al

Saturated vapor pressure of beryllium fluoride.

RUSSIAN JOURNAL OF INORGANIC CHEMISTRY

v. 4, no. 10, p. 998-1000. Oct 1959

The pressure was measured by Knudsen's integral method. The mass of the evaporated substance was obtained from the loss in weight of the effusion chamber with the starting material and by determining the amount of beryllium in the sublimate.

56. Kluiber, R. W. and Lewis, J. W.

Inner complexes. II. Macrocyclic beryllium

chelates and their polymers. AMERICAN

CHEMICAL SOCIETY. JOURNAL v. 82, no. 22,

p. 5777-5779. 20 Nov 1960

Macrocyclic β -dicarbonyl beryllium chelates have been prepared by thermal degradation of the corresponding low molecular weight polymers. These cyclic monomers and dimers polymerize upon heating above the melting points to produce high molecular weight, linear chelate polymers soluble in aromatic solvents.

57. Kripyakevich, P.I., Tylkina, M.A. and Savitskii, E.M.

Structure of hafnium-beryllium compounds (USSR).

ZHURNAL STRUKTURNOI KHIMII v. 2, no. 4,

p. 424-433. July-Aug 1961. (In Russian)

A series of Hf-Be alloys with an Hf content from 0.05 to 95.5% has been studied at L'vov State University and the Institute of Metallurgy imeni A.A. Baykov, Academy of Sciences USSR, by the x-ray diffraction method, microscopic examination, and microhardness measurements. The alloys were melted from iodide Hf and 99.3% pure Be. Four compounds were found: HfBe_2 , HfBe_5 , $\text{Hf}_2\text{Be}_{17}$, and HfBe_{13} . These compounds proved to be of the same type structurally as the respective compounds of the Zr-Be system. HfBe_2 , HfBe_5 , and HfBe_{17} have the same structure as the respective Zr compounds; $\text{Hf}_2\text{Be}_{17}$ has a structure of related type. In all cases the lattice parameters of the Hf-Be compounds are smaller than those of the Zr compounds. An increase in the Be content of the Hf-Be compounds decreases the distance between the Be atoms (HfBe_2 , 2.179; HfBe_5 , 2.17; $\text{Hf}_2\text{Be}_{17}$, 2.14; and HfBe_{13} , 2.07) and increases the distance between the Hf atoms. HfBe_2 has an AlBe_2 -type lattice; HfBe_5 has a CaZn_5 -type lattice; $\text{Hf}_2\text{Be}_{17}$ has a U_2Zn_{17} -type lattice; and HfBe_{13} has a NaZn -type lattice.

58. Kripyakevich, P. I.

Ternary laves-phase in the system manganese-cobalt-beryllium. AKADEMII NAUK URSR.

DOPOVIDI, p. 1042-1044. Aug 1961. (In

Ukrainian)

X-ray determination of a cubic MgCu_2 type phase in the system after 400°C. heat treatment for various times. Data are given for lattice parameters and microstructure.

59. Mackenzie, J. D.

Structure of glass-forming halides. I. Liquid beryllium fluoride. JOURNAL OF CHEMICAL

PHYSICS. v. 32, no. 4, p. 1150-1150. Apr 1960.

59. (cont'd)

Viscosity and electric conductivity measurements have been made on liquid beryllium fluoride over the temperature range 700–950° C. The high specific resistance and viscosity and the magnitude of the corresponding energies of activation indicate that the classical random network structure for glasses is applicable. Liquid beryllium fluoride similar to liquid germanium oxide and silicon oxide, is highly associated even at elevated temperatures. At a temperature 200° above the melting point, the energy of activation for viscous flow is greater than the heat of vaporization. The ease of glass formation is attributed to the network structure of the liquid.

60.

Malik, W. U.

Studies on some less familiar ferrocyanogen complexes. Part IV. Spectrophotometric and conductometric studies on beryllium ferrocyanide. INDIAN CHEMICAL SOCIETY. JOURNAL. v. 38: p. 293–296. May 1961. (In English)

The reaction between potassium ferrocyanide and beryllium chloride was studied spectrophotometrically. From the results it is concluded that decomposition of K_4FeCy_6 is a slow reaction, the reaction is dependent on the concentration of beryllium ions, and it can best be studied at 450m μ . Appearance of the blue color in the slightly acidic solution of potassium ferrocyanide in the presence of beryllium ions was explained on the basis of the decomposition of potassium ferrocyanide and the subsequent formation of prussian blue. Conductometric titrations carried out at 30, 60, and 80° give evidence of the formation of an absorption complex, $K_2BeFeCy_6 \cdot K_4FeCY_6$.

61.

Malik, W. U.

Studies on some less familiar ferrocyanogen complexes. Part V. Interaction of Be(II) and Cr(III) with potassium ferro- and ferri-cyanides at 80° and their composition by amperometry. INDIAN CHEMICAL SOCIETY. JOURNAL. v. 38, p. 297–302. May 1961. (In English)

61. (cont'd)

The reactions of beryllium nitrate and chromic chloride with potassium ferro-cyanide were studied at 80° employing the mercury pool as the reference electrode and potassium chlorate as the supporting electrolyte. Titrations between beryllium nitrate and potassium ferricyanide were carried out at 80°. Evidence for the formation of the complex $K_2Be_3(II)(Fe(II)Cy_6)_2$ was obtained. Conductometric and potentiometric titrations between chromic chloride and potassium ferrocyanide do not give satisfactory results, but the amperometric titrations, carried out at 80°, give evidence for the formation of the complex $KCr(III)Fe(II)Cy_6$. Amperometric studies, carried out under similar conditions, give evidence for the formation of the complex $Cr(III)Fe(III)Cy_6$ by the interaction of chromic chloride and potassium ferricyanide at 80°.

62. Miliotis, J.A., Galinos, A.G. and Tsangaris, J.M.

New complexes of beryllium. SOCIÉTÉ CHIMIQUE
DE FRANCE. BULLETIN, p. 1413-1415. 1961.

(In French)

Halogen acid complexes of beryllium, $HBeCl_3 \cdot 2Et_2O$ and $HBeCl_2Br \cdot 2Et_2O$, and their pyridine salts, $HBeCl_3 \cdot 2py$ and $BHCl_2 \cdot Br \cdot 2py$, were prepared. Infrared spectra are reported.

63. Minné, R. and Rochow, E. G.

Coordination of polymeric organosilyl amines.

II. Reactions with anhydrous beryllium chloride.

AMERICAN CHEMICAL SOCIETY. JOURNAL

v. 82, no. 21, p. 5628-5630. 5 Nov 1960.

Anhydrous $BeCl_2$ reacts with a polymeric silylamine, $(Me_2SiNHCH_2CH_2NH)_n$, in xylene solution to form a coordination polymer in which about one-third of the nitrogen is coordinated to beryllium. The coordinated polymer is more stable towards hydrolysis than the original polymeric silylamine and has very different physical properties. It also differs markedly from the corresponding reaction product of $CuCl_2$ with the same silylamine.

64. Obukhov-Denisov, V. V. et al

The vibration spectrum of vitreous beryllium
fluoride. RUSSIAN JOURNAL OF PHYSICAL
CHEMISTRY v. 34, no. 7, p. 774-775.

July 1960.

Suggestions have been made about the structure of vitreous BeF_2 , based on the analysis of the vibration spectrum and the physicochemical properties. It has been shown that the compound has a structure of an intermediate type, i.e., neither a coordinated nor a molecular structure can be attributed to it.

65. Sen Gupta, A. K.

Complex carbonates of beryllium. SCIENCE AND
CULTURE v. 25, p. 426-427. 1960.

Beryllium compounds which remain in solution after precipitation with alkali metal carbonates, bicarbonates, or $(\text{NH}_4)_2\text{CO}_3$ were found to be complex beryllium carbonate anions. A hydrated, hygroscopic K salt, $\text{K}_6[\text{Be}_4\text{O}(\text{CO}_3)_6]$, was obtained by the dissociation of $\text{Be}(\text{OH})_2$ in KHCO_3 , the Na salt being prepared from NaHCO_3 . The addition of $\text{Co}(\text{NH}_3)_6\text{Cl}_3$ to the beryllium carbonate complex in solution gave either the decahydrate or dodecahydrate of $[\text{Co}(\text{NH}_3)_6]_2[\text{Be}_4\text{O}(\text{CO}_3)_6]$. Both compounds decomposed over a 50° range and the K, Na, and hexamminecobalt (III) salts of the beryllium complex lost H_2O over P_2O_5 . The 2 insoluble hydrated crystals serve for the detection of beryllium by precipitation or microscopic examination. The precipitated beryllium compound can be weighed as the dodecahydrate or determined by titration of the excess acid following dissolution of the complex carbonate.

66. Strukov, B. A., Gavrilova, N. D. and Koptsik, V. A.

Characteristics of the ferroelectric phase transition
in ammonium fluoberyllate crystals. KRISTAL-
LOGRAFIYA v. 6, p. 780 - 782. 1962. (In Russian)

67. Strukov, B. A., Gavriluk, N. D. and Koptsik, V. A.
Some aspects of the ferroelectric phase transition in
(NH₄)₂BeF₄. SOVIET PHYSICS-CRYSTALLOGRAPHY
v. 6, no. 5, p. 625-627. March-April 1962.
68. Strukov, B. A.
Temperature dependence of birefringence in crystals
of ammonium sulfate and ammonium fluoroberyllate.
SOVIET PHYSICS-CRYSTALLOGRAPHY v. 6, no. 4,
p. 511-514. January-February 1962.

The temperature dependence of birefringence have been measured for three cuts of ammonium sulfate and ammonium fluoroberyllate crystals. It has been shown that the temperature change in the path difference of rays is mainly due to the change in refractive indices. Possible temperature dependences have been given for refractive indices of the investigated crystals, qualitatively explaining the experimentally obtained graph of $\Delta n(t)$. It has been shown that in crystals of (NH₄)₂BeF₄, n_x is measured in the \underline{b} direction, and in (NH₄)₂SO₄ crystals in the \underline{c} direction. The possibility has been noted of the optical observation of phase boundaries in (NH₄)₂SO₄ crystals.

69. Talipov, S. T., Podgornova, V. S. and Zinina, G. N.
Solubility in the beryllium-nitrate - lead fluoro-
bromide-water system at 25°. UZBEKSKII KHIMI-
CHESKII ZHURNAL, no. 4, p. 11-16. 1961.
(In Russian)

As the beryllium nitrate concentration increases, the solubility lead fluorobromide increases. By assuming lead fluorobromide to dissociate to $\text{PbBr}^+ + \text{F}^-$, $K_{sp} = 2.22 \times 10^{-6}$, the data are best explained.

70. Tananaev, I. V. and Vinogradova, A. D.
Determination of the composition and stability of
complex ferric and beryllium fluorides in solution
from solubility data. RUSSIAN JOURNAL OF
INORGANIC CHEMISTRY v. 5, no. 2, p. 155-158,
Feb 1960.

The appreciable solubility of CaF_2 in FeX_3 solutions ($\text{X} = \text{NO}_3$, Cl , $1/2 \text{SO}_4$) has been studied in the presence of various anions (Cl^- , SCN^- , F^-), and the results have been used to calculate the values of $K_{\text{FeF}_2} + (\sim 1 \times 10^{-6})$ and $K_{\text{FeF}_2} + (1-2 \times 10^{-9})$. The values of $K_{\text{BeF}_2} + (2.3 \times 10^{-6})$ and $K_{\text{BeF}_2} + (4 \times 10^{-3})$ have been calculated from data for the solubility of CaF_2 in $\text{Be}(\text{NO}_3)_2$ solutions containing NaF .

71. Turova, N. Ya., Novoselova, A. V. and Semenenko, K. N.
Compounds of beryllium chloride with ethers.
RUSSIAN JOURNAL OF INORGANIC CHEMISTRY
v. 5, no. 8, p. 828-831. Aug 1960.

This paper deals with new compounds of beryllium chloride with ethers - dimethyl and dibutyl ether, tetrahydropyran, and 1,2-dimethoxyethane. These are of interest in the study of beryllium halide complexes, as their properties lead to certain conclusions about the influence of the nature of ether on the properties of the complex molecule $\text{BeX}_2 \cdot n\text{R}_2\text{O}$.

72. Turova, N. Ya., Novoselova, A. V. and Semenenko, K. N.
Compounds formed by beryllium chloride with
tetrahydrofuran. RUSSIAN JOURNAL OF INORGANIC
CHEMISTRY v. 4, no. 10, p. 1104-1106. Oct 1959.

The tetrahydrofuran complexes of beryllium chloride were synthesized and their properties were studied. The heats of solution are -7.70 kcal./mole for $\text{BeCl}_2 \cdot 3\text{C}_4\text{H}_8\text{O}$ at -78 to -2° and -7.25 kcal./mole for $\text{BeCl}_2 \cdot \text{C}_4\text{H}_8\text{O}$ at -2 to $+80^\circ$.

73. Turova, N. Ya., Novoselova, A. V., and Semenenko, K. N.

Solubility in the beryllium bromide dietherate-ether system. RUSSIAN JOURNAL OF INORGANIC CHEMISTRY v. 5, no. 4, p. 452-453. April 1960.

The solubility of the beryllium bromide dietherate-ether system has been studied between -50° and $+100^{\circ}$. The existence of a beryllium bromide trietherate has been established; it is converted into the dietherate at -4° . The unit-cell constants of the $\text{BeBr}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$ crystal have been determined.

74. Udalova, V. V.

The superlattice in ammonium fluoroberyllate $(\text{NH}_4)_2\text{BeF}_4$. SOVIET PHYSICS - CRYSTALLOGRAPHY v. 6, no. 4, p. 504-505. January-February 1962.

Data is given on the electron diffraction determination of the unit cell and symmetry of ammonium fluoroberyllate $(\text{NH}_4)_2\text{BeF}_4$ at room temperature.

75. Venkatsubramanian, K.

Crystallographic data - beryllium hydroxysalicylate dihydrate, $\text{Be}(\text{OH})[\text{C}_6\text{H}_4(\text{OH})\text{COO}] \cdot 2\text{H}_2\text{O}$. ANALYTICAL CHEMISTRY v. 32, p. 1052. 1960.

Beryllium hydroxysalicylate dihydrate was prepared according to the method reported (2). It was crystallized from ethyl alcohol and the composition was ascertained by gravimetric methods. The crystal parameters were deduced by indexing the powder photograph by Ito's method (1).

76. Bradshaw, W. G. and Wright, E. S.
REACTION KINETICS OF HIGH-TEMPERATURE
CORROSION OF BERYLLIUM IN AIR. Lockheed
Missiles and Space Co., Palo Alto, Calif. Oct 1961.
5p.

This investigation was undertaken to determine the corrosion rate in air of beryllium at temperatures approaching its melting point. It was carried out in air at near-atmospheric pressures over the range 930-1295°C. The reaction rate was followed by both gravimetric and manometric means.

77. Effect of dodecyl alcohol on fatigue crack propagation. NATIONAL BUREAU OF STANDARDS.
TECHNICAL NEWS BULLETIN v. 45, p. 178-179.
Oct 1961.

Tests are conducted with sharply notched cylindrical specimens of steel, Al, Cu and Be alloys both clean and coated with dodecyl alcohol. Results indicate that the use of alcohol may significantly reduce the rate of fatigue crack propagation due to the fact that the polar compound forms a film on the metal which prevents a corrosive reaction between the metal and the atmosphere.

78. Hanna, G. L.
THE COMPATIBILITY OF BERYLLIUM WITH
OXIDES OF URANIUM AND THORIUM. Institute
of Metals. Conference on Metallurgy of Beryllium,
London, 1961. Preprint no. 18. 1961. 3p.

Preliminary experiments in a study of the compatibility of beryllium with UO_2 , ThO_2 , and their solid solution are described. These concerned the behavior of cermets containing 20 vol.-% UO_2 in beryllium and ThO_2 in beryllium. At 600 and 800°C all samples swelled so rapidly that the use of such cermets at these temperatures appears impracticable.

79.

Levy, D. J.

THE ELECTROLYTIC POLARIZATION OF

BERYLLIUM. Lockheed Aircraft Corp.

Sunnyvale, Calif. Report no. LMSC-6-90-61-75.

Nov 1961. 2p. ASTIA AD-267976.

The anodic and cathodic polarization behavior of beryllium was determined in a number of unstirred aqueous electrolytes at 22 C with current densities in the range of 10 to the -7th power to 10 to the -2nd power amps/per square centimeter. CrO_4 and PO_4 ions induced considerable anodic polarizations. There was some evidence that the anodic potential was increased due to beryllium film formation in the presence of CrO_4 , NO_3 , AlO_2 ions. A Flade Potential was not observed. Beryllium was activated and attacked anodically in the presence of Cl , and ClO_3 , F and SO_4 ions. Other ions investigated were B_4O_7 , $\text{C}_2\text{H}_3\text{O}_2$, CO_3 , MnO_4 , OH , and SiO_3 . Na_2CrO_4 was an effective cathodic polarizer over a broad range of current densities. Most of the electrolytes exhibited a common Tafel region for hydrogen evolution. Some the corrosion aspects of the solutions are also discussed.

80.

Maak, F.

Evaluation of film thickness measurements on

binary alloys with internal oxidation and simul-

taneous external oxidation. ZEITSCHRIFT FUER

METALLKUNDE. v. 52, no. 8, p. 545-546.

Aug 1961. (In German)

Computation of oxygen solubility as a function of diffusion in a binary Cu-Be alloy (0.77-6.6 at. % Be) oxidized at 850° C. by microscopic measurement of zone of internal oxidation.

81. Phennah, P.J., Davies, M.W. and Woodfine, B.C.

THE OXIDATION OF BERYLLIUM IN CARBON

DIOXIDE. General Electric Co., Ltd., Atomic

Energy Division, Erith, Ken, England. October

1961. 6p.

The oxidation behavior of two samples of commercial beryllium in CO₂ and in CO₂/H₂O and CO₂/CO/H₂O mixtures at pressures up to 150 lb/sq. in. has been studied over the temperature range of 600-750° C. The extent of oxidation was assessed by weight-gain measurements and by metallographic examination, and the oxide scales were also examined by X-ray and electron-diffraction techniques. The two samples of beryllium were fabricated from powder off the same specification by hot pressing and by cold pressing, sintering, and warm extruding, respectively. With dry CO₂ the oxide was protective, but in a number of tests rate transitions were observed. In the CO₂H₂O mixtures the oxidation rate initially decreased with time but eventually breakaway oxidation, i.e., an accelerating rate, occurred. The time to the onset of breakaway oxidation was related to the temperature and to the gas composition. The mechanism of the oxidation process is discussed with particular reference to the occurrence of breakaway oxidation.

82. Smith, R. et al

INHIBITION OF BREAKAWAY OXIDATION OF

BERYLLIUM IN CARBON DIOXIDE. Australian

Atomic Energy Commission, Lucas Heights,

Australia. October 1961. 5p.

Oxidation tests have been made at 700° C in carbon dioxide containing 2 percent water vapor to investigate the effects of intergranular oxide content on the "breakaway" or rapidly accelerating type of oxidation observed when beryllium is oxidized in wet carbon dioxide. Weight-gain/time curves were determined for different materials, and the nature of the processes was investigated by metallography combined with electron and x-ray diffraction. It was found that breakaway oxidation was effectively inhibited in beryllium made from powder which, before consolidation, was oxidized at 800° C in oxygen for 1/2 to 1-1/2 hours.

83. Antill, J. E. and Higgins, J. K.

OXIDATION OF BERYLLIUM. Oak Ridge National

Laboratory, Tenn. TID-7579. 26 Feb 1960, 9p.

The object of the work reported in this paper was to extend the data for the behavior in carbon dioxide and oxygen to longer times of exposure and to determine the influence of variables in the fabrication of beryllium sheet. Rates of oxidation have been obtained for samples fabricated by different routes in carbon dioxide at 500-1000°C, oxygen to 700°C, and carbon dioxide containing water vapor at 700°C. for times up to 5000 hours.

84. Werner, W. J. and Inouye, H.

THE REACTIONS OF BERYLLIUM WITH WET

CARBON DIOXIDE. Oak Ridge National Lab-

oratory, Tenn. Oct 1961, 5p.

The reactions of beryllium with wet and dry CO₂ were found to be parabolic in the temperature range 550-720° C for times up to 1000 hours. At 725° C, a "break-away" reaction was observed in wet CO₂ after 60-70 hours. Reaction products were found to be BeO and Be₂C, both increasing with time and temperature. The reactions between beryllium, which contains carbon as an impurity, and wet helium were characterized by an initial rapid rate of reaction followed by a protective type of oxidation similar to that observed in dry CO₂. This behavior is believed to be associated with decarburization during the early stages of the tests.

FABRICATION TECHNIQUES

85. Beaver, W. W.

WROUGHT FABRICATION OF BERYLLIUM

METAL. Institute of Metals. Conference of

Metallurgy of Beryllium, London, 1961. Pre-

print no. 68. 1961. 2lp.

The fabrication of beryllium through deformation at elevated temperature by many of the commercial metal-working techniques is described. Joining by arc welding, resistance welding, brazing, adhesive bonding, and mechanical fastening is also covered. The factors affecting fabrication are considered, and data are presented

85. (cont'd)

on the influence of raw material upon deformation by different wrought fabrication techniques. During fabrication the amount of residual cold work, grain orientation substantially influence the resulting mechanical properties. Methods of working, heat-treatment, and grain-size-control techniques showing promise in alleviating anisotropic distribution of properties, are described.

86. Beryllium bare-forged after 1400° F. preheat.

SPACE AERONAUTICS v. 36, p. 162. Oct 1961.

Process reduces production costs and improves ultimate tensile and yield strengths and elongation. Technique includes dimensional and fluorescent die penetrant inspection.

87. Brayman, J.

Aspects of heavy press utilization. MECHANICAL

ENGINEERING v. 83, p. 50-51. Sept 1961.

Die forging and deep drawing of Ti, Al, Be, V, Mo, W and stainless steel into panels used in space craft, missiles and tanks. Data are given for rigidity and tensile strength of the metals.

88. Brock, P., Bowers, J.E., and Smith, D.D.

A machine for correcting the shape of strip.

INSTITUTE OF METALS. JOURNAL v. 90,

p. 1-6. Sept 1961.

Design and application of a stretching device which consists of a number of small rods, followed by a series of progressively larger straightening rolls, over which metal strip can be pulled under tension resulting in correction of bad strip shape and the inherent tendency to edgewise bow on subsequent slitting. Application in straightening and flattening bronze, brass, Be-Cu, Al and mild steel. Soft material is slightly hardened by treatment in the machine, but the properties of half-hard, or harder, material are not significantly affected.

89. Cieslicki, M. E.
BERYLLIUM FORGING. Wyman Gordon
Company, Worcester, Mass. 18 Oct 1961.
8p.

The fabrication of components of beryllium is discussed. With the purity level obtained in commercial practice and with the absence of an ingot-casting method that yields a forgeable product, powder, powder-metallurgy techniques have been utilized. The shortcomings of the press-sintering technique gave reason to develop a new method using pressures in the range of 20,000-100,000 lb/sq. in., sintering times from 1 second to 1 minute, and two temperature ranges (1600° and 1900° F).

90. Denny, J. P. and Rubenstein, H. S.
THE FORGING OF JACKETED AND BARE
BERYLLIUM. Institute of Metals. Conference
on Metallurgy of Beryllium, London, 1961. Pre-
print no. 54. 6p.

Forging techniques for beryllium are discussed, and typical mechanical properties are presented. Forged beryllium exhibits UTS values of 52,000-67,000 lb/in², YS of 40,000-50,000 lb/in², and elongations of 1.5-4.0%. These properties are superior to those of hot-pressed beryllium powder. The forged material normally has directional properties, and forging flow lines may be observed under polarized light. Cladding is useful in providing support during deformation, avoiding galling, minimizing toxicity problems, and acting as a container for powders during forging, but it raises costs and makes control of tolerances difficult.

91. Eaton, N. F., Longstaff, D. A. and Robinson, J. A.
PRODUCTION AND PROPERTIES OF BERYL-
LIUM INGOTS MADE BY CONSUMABLE-ELECTRODE
ARC MELTING. Institute of Metals. Conference
on Metallurgy of Beryllium, London, 1961. Pre-
print no. 65. 1961. 6p.

91. (cont'd)

An assessment is made of various casting methods and a description given of the consumable-electrode vacuum-arc furnace used for beryllium. Vacuum-cast beryllium is lower in impurities, particularly oxygen, than powder-fabricated beryllium and this results in improved properties. Mechanical-test results are quoted.

92. Electric discharge drilling beryllium.

LIGHT METAL AGE v. 19, nos. 11-12,

p. 25. Dec 1961.

The Beryllium Corporation has placed in operation at its Hazelton, Penna, fabricating plant, a new electric discharge machine which blasts holes in pure beryllium metal under precisely controlled conditions and to extremely close tolerances.

93. Eyre, P. B.

Facilities for the fabrication of beryllium.

In INTERNATIONAL SYMPOSIUM ON FUEL-

ELEMENT FABRICATION, VIENNA, MAY

1960. PROCEEDINGS 1961. p. 403-417.

(In English)

Facilities required to fabricate and test beryllium are considered. Toxicity and maximum tolerance levels are considered; building and equipment designs are given, including suitable protective enclosures, glove boxes, hoods, and ventilation-system details. Cost factors involved as a result of the metal toxicity are listed.

94. Farthing, T.W., Eyre, P.B. and Terry, C.A.

THE FABRICATION OF BERYLLIUM FOR

REACTORS. Institute of Metals. Conference

on Metallurgy of Beryllium, London, 1961.

Preprint no. 64. 1961. 11p.

94. (cont'd)

Current manufacturing techniques for producing tubes, rods, and billets are described under: (1) consolidation practice, including melting, swarfing, and grinding practices for production of powder, together with loose (or pressureless) sintering and hot pressing; (2) mechanical working—extrusion and subsequent manipulation of the products. Details are given on preparation for extrusion, which includes machining and electroplating. Hot extrusion of beryllium clad in steel, and warm extrusion without steel cladding in the range 700–850° C are described. The importance of quality control at all stages is stressed, and various types of specialized equipment needed to maintain the quality of beryllium in both powder and consolidated forms are described.

95. Feith, A. D.

TAPPED HOLES IN BERYLLIUM. General

Electric Co. Flight Propulsion Laboratory Dept.,

Cincinnati, Ohio. Report APEX-649. 10 July 1961.

21p. (Contracts AF 33(600)-38062 and AT (11-1)-

171)

Preliminary studies were carried out to determine the feasibility and the necessary design parameters for tapping threaded holes in beryllium. Data are given for the torque and tensile testing of the bolted beryllium samples. The results indicate that internal threads in beryllium are feasible.

96. Fugardi, J. and Sheinhart, I.

ISOSTATIC FORMING OF BERYLLIUM.

Sylvania Electric Products, Inc., Sylcor Division,

Bayside, N. Y. SCNC-322. Feb 1961. 45p.

(Contract Nord-17017)

The feasibility of using the isostatic forming process to fabricate beryllium parts has been demonstrated on two specific parts. These were a cylindrical tube with a closed hemispherical end and a cylindrical tube with a 16 degree funnel section. Tests made on sections of isostatically formed beryllium indicate that it has properties equivalent to conventional hot pressed material in respect to yield strength, tensile strength and elongation.

97. Guest, J. C. et al

THE PRODUCTION OF BERYLLIUM ROD AND

TUBING. Tube Investments Technological Centre,

Walsall, Staffordshire, England. Oct 1961. 7p.

A pilot plant and processes for the production of beryllium rods, tubing and sections are described. Preparation of billets for extrusion and subsequent processing are carried out in specially contained and ventilated plant, to overcome the health hazard. Process stages include powder consolidation by pressureless sintering, hot-sheathed extrusion, sheath removal by pickling, and finishing operations. The choice of material and design for billet sheathing is discussed. Process inspections and metallurgical controls which insure form quality of the finished product are described.

98. Hayes, A. F. and Yoblin, J. A.

NEW CONCEPTS FOR FABRICATING BERYL-

LIUM THROUGH ADVANCED FORGING AND

POWDER-METALLURGY TECHNIQUES.

Institute of Metals. Conference on Metallurgy

of Beryllium, London, 1961. Preprint no. 53.

1961. 13p.

Using specially designed closed-impression forging dies and vacuum hot-pressed block or shaped powder-metallurgy preforms, and selecting suitable temperatures based on ductility and v.p., successful forgings can be made with 100% theoretical \bar{d} and superior properties. The preforms can be mechanically or isostatically pressed or slip-cast, and sintered. Vacuum sintering is designed to minimize volatilization and effect final sintered \bar{d} ranging from 75 to > 95% of theoretical \bar{d} . The rate of deformation and the special treatment of surfaces which are in tension while being deformed are important in individual cases. The use of sintered preforms which are moulded or slip-cast with a specific shape allows complicated forgings to be produced with close dimensional control.

99. Hebel, H. K.
A NEW STRUCTURAL CONCEPT TO CAPITALIZE ON THE POTENTIAL LIGHT WEIGHT OF BERYLLIUM. The Boeing Company, Seattle, Wash. Oct 1961. 19p.

A method new to the fabrication of beryllium is presented which minimizes the shortcomings of beryllium through the use of beryllium sheet bonded to the aluminum substructure. In the design concept shown, the brittle beryllium contains no stress concentrations. Instead, these are confined to the ductile aluminum. Since no beryllium machining is required, the cost and hygiene barriers are reduced. Current missile structural designs using machined sintered block materials have greater brittleness, much greater costs, and toxicity disadvantages as well as lower strength than the newer sheet-material design. Three beryllium interstages of this design have been fabricated and tested successfully under axial load as reported herein. One interstage contained a large bolted access door and bolted attachments to the forward and aft engines. The weight penalties of additional pieces of aluminum substructures did not significantly alter the ideal weight saving initially shown possible.

100. Hessler, B. H. and Denny, J. P.
BERYLLIUM CASTING. Beryllium Corp., Reading, Penna. Interim Technical Engineering Report No. 10, Reporting Period, 5 July 1961 to 4 Nov 1961. 27p. (Contract AF 33-(600)37902). ASTIA AD-266 741.

Methods were developed for the production of sound three-inch diameter vacuum-cast beryllium billets suitable for fabrication. The casting technique relies on a thermal gradient within the mold (hot top, cold bottom) to control directional solidifications of the metal and eliminate the centerline shrinkage encountered in conventionally cast billets. The thermal gradient casting technique has been found to be reliable and reproducible. Ingots produced by this process show no indication of cracking as determined by radiographic tests and sectioning. Flat beryllium slabs have also been cast using this technique, and these are now being evaluated for soundness.

101. Hessler, B. H. and Denny, J. P.
Fabrication of beryllium sheet from hot pressed powder. In PROGRESS IN POWDER METALLURGY v. 17, Metal Powder Industries Federation, New York 17, 1961, p. 5-11.

Hot rolling at 1400-1800°F. of hot pressed and sintered Be slabs after machining and cladding with mild steel (the cladding being removed after rolling by hot shearing and stripping). Influence of microstructure, grain size, orientation, reduction ratio, rolling direction and recrystallization annealing at 1500° F. on yield and tensile strengths, ductility, elongation and crack susceptibility.

102. How non-chemical explosions shape hard-to-form metals. IRON AGE v. 188, no. 17, p. 88-89. 26 Oct 1961.

Electro-hydraulic operating principles and procedures for capacitor-discharge plant equipment used to form, weld, bond and pierce ceramics and metals including Al, Ti, Be, Co and stainless steel.

103. Julien, H. P., Thomas, P. R. and Thomson, G. W.
New grit grinds tough alloys. AMERICAN MACHINIST/METALWORKING MANUFACTURING v. 105, p. 62-63. 25 Dec 1961.

Grinding of beryllium, hardened V steel and toolsteel using fused alumina abrasive with improved resistance to breakdown and longer retention of sharpness.

104. Kunkler, W. C., Jr. and Canal, J. R.
Forgings for missiles and space vehicles.
MECHANICAL ENGINEERING v. 83, p. 45-49.
Sept 1961.

104. (cont'd)

Die forging, roll forming, extruding and machining of Be, Ti, Ni-base alloys, refractory metals and low-alloy steel. Tensile and stress-rupture properties are given for Be and Ni-base forgings.

105.

Kyffin, P. D. and Craik, R. L.

CONSUMABLE-ELECTRODE, VACUUM ARC-

MELTING OF BERYLLIUM. Institute of Metals.

Conference on Metallurgy of Beryllium, London,

1961. Preprint no. 49. 1961, 7p.

Beryllium ingots of up to 3 kg were prepared by vacuum arc-melting consumable electrodes made from compacted, compacted and sintered, and vacuum-induction-melted and cast beryllium powders (electrolytic and thermally reduced). In all cases, metallographic examination showed a greater degree of grain refinement in arc-melted metal when compared with vacuum-induction-melted and cast metal. The rapid rates of solidification in arc melting, however, create thermal stresses leading to micro-fissuring, which may be identified with brittle fracture along the (0001 and 1120) fracture planes of the beryllium crystal structure as well as at grain boundaries.

106.

McClelland, J. D. and Smith, W. M.

RESEARCH HOT PRESSING. Atomics Inter-

national, Div. of North American Aviation,

Inc., Canoga Park, Calif. Report NAA-SR-6441.

30 Oct 1961. 19p. (Contract AT(11-1)-GEN-8)

The construction and operation of a hot press suitable for the preparation of specimens of refractory inorganic materials is described. Use of such equipment permits the fabrication of materials of high density and controlled grain size which are difficult to fabricate by other means. The theoretical aspects of hot pressing are discussed. The use of a plastic flow model of hot pressing to describe quantitatively the variation of the end point density of materials is described. Typical data on the temperature and pressure dependence of the density of alumina and beryllia are given.

107. McClelland, J. D. and Zehms, E. H.
SEMI-CONTINUOUS HOT PRESSING. Atomics
International. Division of North American
Aviation, Inc., Canoga Park, Calif. Report
NAA-SR-6453. 15 Nov 1961. 14p. (Contract
AT-11-1-GEN-8)

Equipment and techniques used in the semi-continuous hot pressing are described. Preliminary data are presented on the effect of time and temperature on the final density of high-purity beryllia. Densities of greater than 98% were achieved, at temperatures as low as 1100° C, and at time cycles as short as 11 min. The conclusions was reached that, under suitable conditions, semi-continuous hot pressing can compete both technically and economically with sintering techniques.

108. Mayer, L. W.
Heavy presses in the space age. MECHANICAL
ENGINEERING v. 83, p. 44-45. Sept 1961.

Space craft components are forged and extruded on presses from Be, Ti alloys, Ni-base alloys, refractory metals, Mg, Al, low-alloy steel and stainless steel. Effect of chemical composition and forging pressure on ductility and forgeability.

109. Munro, W. and Hill, N. A.
IMPROVEMENT IN OR RELATING TO THE
FABRICATION OF BERYLLIUM. British Patent
884,108. 6 Dec 1961.

A method is given for production of beryllium tubing with good ductility at right angles to the extrusion direction. The method comprises boring out a central hold in an extruded beryllium rod to form a billet, and then extruding the billet to give a reduction in cross-sectional area of not more than 15 to 1. The billet may conveniently be extruded to form a tube of the same internal diameter as that of the billet, but of reduced external diameter. This method results in a considerable saving in material as compared with boring out a rod without subsequent extrusion.

110. Nakatani, H.

Studies on sintering of beryllium powder. III.

On the pretreatment of beryllium powder for
sintering. DENKI SHIKENSHO IHÔ v. 25, no.
8, p. 605-610. Aug 1961. (In Japanese)

The pretreatment of beryllium powder for sintering was studied. Using ethylene dibromide-benzole mixed solution, a method of separation by specific gravity was carried out to separate the impurities mixed in the process of mechanically reducing the fused salt electrolytic flakes or the particle control process. In order to refine the particle surface, concentrated nitric acid was used. Spectral analysis of this pretreated powder showed effective results when compared with the reduced powder.

111. O'Neill, J. S. and Livey, D. T.

IMPROVEMENTS IN OR RELATING TO MOULDS
FOR HOT PRESSING POWDERED MATERIALS.

British Patent 878,088. 27 Sept 1961.

Descriptions are given of a molding process and graphite molds for hot pressing powdered refractory material (beryllium oxides) into dense tubes. The core consists of a hollow graphite shell of thickness such that it will withstand the hot pressing operation (1400 to 1800° C), but crushes (subsides) under the contractural load on cooling. Graphite core sizes are given for beryllium oxide tubes of length 1 to 1-1/2 inches and 1/3 to 1 inch ID.

112. Paprocki, S. J., Hodge, E. S. and Perrin, J. S.

PRELIMINARY STUDIES OF BONDING OF BERYLLIUM-CLAD UO_2 FUEL ELEMENTS. Battelle
Memorial Institute, Columbus, Ohio. Report
BMI-1545. 20 Sept 1961. 20p. (Contract W-7405-eng-92)

112. (cont'd)

Gas-pressure bonding was investigated as a fabrication technique for the solid-state bonding of beryllium. Bonding parameters, surface-preparation methods, and compatibility of beryllium with UO_2 and with several contained and barrier materials were studied. Beryllium-to-beryllium bonds were obtained after 2 to 4 hours at 1500 to 1650° F. at 10,000 psi. Bonds produced with grit-blasted and abraded specimens exhibited recrystallization of grains at the original interface. The interface did not appear weaker than the parent metal during limited mechanical testing. Chromium or pyrolytic carbon coatings on UO_2 cores prevented significant UO_2 -beryllium reactions during bonding for four hours at 1650° F. and 10,000 psi. Reaction products formed on the beryllium surface during compatibility experiments with other materials were easily removed by acid pickling.

113. PROCEDURE FOR OBTAINING DIRECTLY BERYLLIUM USING ANY MISCIBLE METAL, INCLUDING PURE BERYLLIUM. Italian Industrial Patent 349,185
(Addition to Patent 342,591) 9 June 1937. 10p. (In Italian); (French trans. by L. Roulet. CEA-tr-X-256)

A method is given of the direct production of beryllium alloys with beryllium concentrations greater than 25%. The method consists in the reaction of a beryllium compound or mineral with a scorifying metal or metalloid in alloy having initially a specific weight higher than the beryllium compound used. Just below the fusion temperature of the scorifant, the reaction mass is violently agitated either by mechanical means or by electromagnetic induction. An almost maximum yield of the pure beryllium or the alloy is obtained. In an addendum to the original patent, it is reported that the process is facilitated if the alloying element is in a eutectic medium and if the medium melts at a temperature much lower than the fusion temperature of the components.

114. Randall, R. N. et al

 FUNDAMENTAL AND APPLIED RESEARCH

 AND DEVELOPMENT IN METALLURGY;

 EXTRUSION BY HYDROSTATIC PRESSURE.

 Nuclear Metals, Inc., Concord, Mass. Report

 NMI-1250. 13 July 1961. 34p. (Contract

 AT(30-1)-1565)

Experimental extrusions were made from a container in which the billets were surrounded by a fluid under hydrostatic pressure. Copper, aluminum, mild steel, yttrium, and beryllium billets were extruded at room temperature at various reductions. Attempts to extrude at 900° F from a container filled with liquid lead were unsuccessful because of the failure of the containers at pressures greater than 10,000 psi. The pressures required for extrusion of copper and aluminum were approximately the same as were required for extrusion by conventional means.

115. Sheinhart, I.

 THE FABRICATION OF BERYLLIUM BY HOT

 ISOSTATIC PRESSING AND BY IMPACT EXTRU-

 SION. Sylvania Electric Products Inc., Sylcor

 Div., Bayside, N.Y. Report SCNC-332. Sept

 1961. 42p. (Contract AT(38-1)-200, Subcontract

 40-9-11 for General Nuclear Engineering Corp.,

 Dunedin, Fla.)

The feasibility of producing a finned beryllium tube by the hot isostatic pressing of beryllium powder was demonstrated. The powder was pressed directly into the final shape so that only a minimum of machining would be required. Hot pressed beryllium billets and porous cold compacted billets were extruded by the Dynapak. The mechanical properties of the extruded material depended on the extrusion temperature and the density of the compact.

116. Sherwood, E. M.
Less common metals. INDUSTRIAL AND
ENGINEERING CHEMISTRY v. 53, p. 922-924.
Nov 1961.

A review is given on developments and improvements in process technology for fabricating beryllium...The references given cover the period June 1960 through May 1961.

117. Sherwood, E. M. and Secrest, V. S.
PRODUCTION AND AVAILABILITY OF SOME
HIGH-PURITY METALS. Battelle Memorial
Institute. Defense Metals Information Center,
Columbus, Ohio. DMIC-Memo-76. 2 Dec 1960.
61p. (PB-161226)

A review is presented of production techniques and the availability of high-purity beryllium....

118. Tatman, M. E.
BERYLLIUM FABRICATION TECHNOLOGY.
Lockheed Missiles and Space Co., Sunnyvale,
Calif. Oct 1961, 8p.

The development of materials capable of withstanding the thermal-structural environments of missile light is discussed. Because of its characteristics, beryllium appeared attractive and was immediately considered. However, at that time, beryllium was relatively unknown and data on design and fabrication was limited. The extensive development effort which qualified beryllium as a suitable material for use on missiles and space craft is described. As reported in this paper, alternative types of forming and joining methods were investigated. Methods of forming included hot-formed plate, hot-pressed canned material, back-extrusion, and high-temperature isostatic pressing. Joining methods investigated included brazing, arc welding, adhesive bonding, and mechanical methods.

119. Van Houten, G. R., White, J. F. and Botje, J. M.
FORMAT OF ALUMINA COATINGS ON BERYLLIA
BY A VAPOR DEPOSITION PROCESS. General
Electric Co. Flight Propulsion Laboratory Dept.,
Cincinnati, Ohio. Report APEX-699. 30 June 1961.
78p. (Contracts AF 33(600)-38062 and AT(11-1)-171)

The theoretical and experimental work performed in developing a manufacturing process for cladding BeO and BeO base tubes with α -alumina (corundum) is described. The process employs the formation of alumina from the vapors of aluminum chloride according to the reaction $2\text{AlCl}_3 + 3\text{H}_2 + 3\text{CO}_2 \rightarrow \text{Al}_2\text{O}_3 + 3\text{CO} + 6\text{HCl}$. Suitable process gas compositions and process temperatures for depositing approximately 0.001 inch of dense α -alumina per hour were determined. It was further established that: the production of water vapor by reacting H_2 and CO_2 is the critical rate determining step in the process. Carbon monoxide depresses the rate of alumina deposition. High hydrogen concentrations promote the formation of water vapor by reduction of carbon dioxide. Depending on the process gas composition and operating variables different crystal forms of alumina can be obtained. The recommended operating procedure process α -alumina having a density of 4.00 gms/cm³. The use of graphite or carbon components of the apparatus causes the formation of carbon monoxide which suppresses the rate of alumina deposition but this effect can be reduced by adding excess H_2 and coating the graphite parts with Al_2O_3 . A pilot run is described during which the bores of approximately 700 tubes were coated with α Al_2O_3 to a thickness of 0.0006 inch.

120. Wood, W. W., Goforth, R. E. and Ford, R. A.
A PE special report on theoretical formability.
PRODUCT ENGINEERING v. 32, p. 71-83.
16 Oct 1961.

Design charts are used to predict sheet metal forming failures by splitting or buckling. Forming methods include brake forming, deep drawing and spinning, dimpling, rubber stretch and shrink flanges, joggling, linear stretch heel-in, sheet stretch and beading rubber press. Sheet materials include Al, Ti, Mg, Be, V, Nb, W and Ni alloys and superalloys.

121. Wright, D. B. and Ellis, G. C.
AN EVALUATION OF BERYLLIUM TUBE-
FABRICATION METHODS. Institute of Metals.
Conference on Metallurgy of Beryllium, London,
1961. Preprint no. 63. 1961. 26p.

Using mainly vacuum-cast electrolytic-flake beryllium, a variety of tube-fabrication techniques were evaluated. Two distinct temperature ranges were employed, above and below the recrystallization temperature. Normal "hot-working" processes such as hot extrusion were carried out, but at the lower "warm-working" temperature normal cold-working techniques, such as drawing, were used. The final products were examined metallographically and by x-ray techniques, to determine grain structure and orientation.

122. Wright, W. J. and Silver, J. M.
THE EXTRUSION OF BERYLLIUM. Australian
Atomic Energy Commission, Lucas Heights,
Australia. Oct 1961, 4p.

The equipment and technique for the extrusion of beryllium within a mild steel sheath are described, and the limitations of the techniques are discussed. The use of a lead glass as a lubricant reduces the extrusion pressure for mild steel by 15 percent at 1050° C; the advantages of the application of glass lubricants in the extrusion of beryllium without a mild steel sheath are discussed.

JOINING

123. Fisher, J. G.
New aluminum alloy solves weld heat-treat
problem. SPACE AERONAUTICS, v. 36,
p. 87-94. Oct 1961.

Comparison of welding tests of Tens 50, an Al-Mg-Si alloy modified by Na and Be, with other weld-filler materials for aerospace systems. Design of assemblies using the alloy and methods of welding and heat treatment.

124. Hess, W. T. et al
ELECTRON-BEAM FUSION WELDING OF
BERYLLIUM. Alloyd Corp., Cambridge, Mass.
Oct 1961, 4p.

The prime causes of autogenous weld failure in the metal beryllium are vaporization, out-gassing, thermally induced stress-crackling, and excessive grain growth. Electron-beam welding provides a means of obviating these problems. Necessary to successful welding is the control of heat flow, chamber pressure, and weld-energy input. Welds can be made which are mass-spectrograph leak-tight and exhibit base-metal mechanical properties. A discussion of techniques and results will be presented as applied to hot-pressed and to rolled-sheet material.

125. Malhomme, P. and Thome, P.
THE WELDING OF BERYLLIUM CANS. Centre
d'Etudes Nucleaires de Saclay, Gif-sur-Yvette,
France. Oct 1961, 4p.

Work on the welding of beryllium was undertaken with a view to the possible application of EL-4 fuel elements, one of the suggested versions of which consists of an assembly of rods sheathed in beryllium. In this study two types of fusion welding were considered: one involving electron bombardment and the other inert-gas arc welding. The tests were made on two types of closure: welding from above and lateral welding, both preceded by various surface treatments, namely, chemical cleaning, electrolytic polishing, or simple degreasing. A study of the effect of non-metallic impurities on welding has also been begun.

126. Marcellin, W. J.
AUTOMATIC AND MANUAL BRAZE-WELDING
TECHNIQUES FOR BERYLLIUM. University of
California, Livermore, Calif. Oct 1961, 6p.
(Contract No. W-7405-ENG-48)

126. (cont'd)

Procedures for braze-welding beryllium by the tungsten-arc (non-consumable electrode) and metal-arc (consumable electrode) inert-gas-shielded processes are described. These procedures provide for two general fabrication conditions for the purpose of controlling base-metal temperatures and limiting base-metal cracking. These conditions limit the braze-welding heat inputs above and below 2500 joules/in. of weld. Braze-welds are made with aluminum-5 or 12 percent silicon alloy or 99.9 percent pure silver as the braze material. The natures of the various welding arcs are discussed and data presented to show their effects on the beryllium micro-structure. High-speed photographs show the metal transfer of dip and spray consumable-electrode arcs. The equipment necessary to obtain the required arc characteristics is considered.

127. Mercury metals - "A-OK."

UNION CARBIDE METALS REVIEW v. 4, p. 10-12.

Fall 1961.

Fusion, seam and spot welding of Ti sheet and rings, 5Al-2, 5Sn Ti alloy, Haynes R 41, beryllium shingles and billets and stainless steel-encased thermal insulation in the fabrication of space capsules resistant to high take-off and reentry pressures of 20 G's and temperatures of 11,000° F.

128. Vickers, W.

AN INVESTIGATION INTO THE BRAZING OF

BERYLLIUM. English Electric O., Ltd., Atomic

Power Division, Whetstone, Leicester, England.

Oct 1961, 5p.

Attempts to braze beryllium have been carried out using a variety of braze metals. Successful joints were obtained with H10, SCP3, silver, SCP5, and SCP6 alloys. The brazing temperature of these alloys varied from 800-1100° C. On annealing specimens in dry CO₂ (less than 10 ppm water) at 600° C., there was severe attack at the beryllium/braze interface. The results are discussed from the brazing viewpoint and in terms of using brazed joints in an advanced gas-cooled reactor.

129.

Westlund, E. F.

VACUUM FURNACE BRAZING OF BERYLLIUM.

University of California, Livermore, Calif.

Oct 1961, 5p. (Contract No. W-6405-ENG-48)

Vacuum brazing techniques have been developed for joining beryllium to titanium, stainless steel, and to itself using silver as the filler. Shear strengths of about 20,000 lb/sq in. were obtained for all three types of brazes. When brazing beryllium to titanium or to stainless steel, excessive brazing temperatures or holding times result in low-strength brazes. Both brazes can be made at temperatures as low as 900°C, which is 60° below the melting point of pure silver. Initially, difficulty was experienced in obtaining consistently good brazes when joining beryllium to itself owing to poor wetting by the silver. This was overcome by adding a small amount of titanium hydride to the beryllium contact surface. High-strength brazes were consistently produced by this method at temperatures from 960° to 1070° C, showing that overheating was not a problem.

MINERALOGY

130.

Beus, A. A.

GEOCHEMISTRY OF BERYLLIUM AND GENETIC

TYPES OF BERYLLIUM DEPOSITS. Moscow,

Izdatel. Akademiia Nauk SSSR., 1960, 557p.

(In Russian)

131.

Beus, A. A.

Main features of beryllium geochemistry in the hydrothermal-pneumatolytic process. INSTITUT MINERALOGII, GEOKHIMII I KRISTALLOKHIMII REDKIKH ELEMENTOV, VOPROSY MINERALOGII, GEOKHIMII I GENEZISA MESTOROZHDENII REDKIKH ELEMENTOV. TRUDY, no. 2, p. 7-18, 1959.

(In Russian)

In the presence of mineralizers such as fluorine, and under conditions excluding formation of pegmatities, beryllium, together with W, Pb, and Mo, passes into the pneumatolytic phase and concentrates in hydrothermal veins and in the products of pneumatolysis of granitic magma. For most deposits the distinct relation of beryllium and fluorine is characteristic. Processes of acid postmagmatic leaching followed the albitization and are usually restricted to the uppermost part of the granitic rocks. The main factor of beryllium migration during postmagmatic stage is the alkalinity of mineralizing solutions. Two zones of beryllium concentration are observed in greisen bodies. The first corresponds to the outer part of a greisen and has a quartz muscovite composition. The beryllium concentration here occurs under conditions of sharply decreased acidity of greisenizing solutions. The second zone of beryllium concentration is the region of fractures in the central part of greisen body; but neutralization of solutions in fractures is due to elimination of fluorine, which with decreasing temperature and acidity of mineralization solution becomes bound to aluminum in the inner quartz-topaz and topaz zones of greisen. The change in Si:Al ratio in solutions during metasomatism resulted in the formation of different beryllium minerals. In different types of Kazakh skarns, the beryllium minerals are characterized by the Si:Al ratio. Skarns containing chrysoberyl have atomic ratios of Si:Al (0.3-1.1). When in the same deposit the skarns with helvite are considerably more acid, then their Si:Al = 2-3.5. The data suggest that there is no relation between iron concentration in the contact metasomatism, and their simultaneous accumulation in fluorite-magnetite ores is due to the action of fluorine-containing solutions capable of transporting together with beryllium a considerable amount of iron. Therefore, accumulation of beryllium in contact metasomatic formations, as in the other high temperature hydrothermal pneumatolytic deposits, is determined, entirely by the action of the postmagmatic fluorine-containing exhalations and the solutions of the acid stage of metasomatism.

132.

Bugel'skii, Yu. Yu.

Prospects of a hydrogeochemical beryllium

exploration. AKADEMIYA NAUK SSSR.

MATERIALY GEOLOGIIA RUDNYKH MESTORO-

ZHDENII, PETROG. MINERALOGIIA I

GEOKHIMIIA. 1959. p. 187-190. (In Russian)

The hydrochemical methods of ore exploration were recently introduced into practice, and in beryllium prospecting they seem to be very promising, although the supergene beryllium migration is not sufficiently studied. The spectral analysis of ground water sometimes indicates 0.2 mg. of Be/l, which is 100 times greater than its average content in earth rocks. Of the 693 analyses of water from various localities in U.S.S.R. given, 49 contained no more than 0.000n% and only 17 from the rare elements deposits of the Kazakhstan showed 0.00n-0.0n% beryllium. It is proposed to consider the values smaller than 0.000n% beryllium as background contents, and that of 0.00n-0.0n% as anomalous ones, suggesting either beryllium mineralization or an increased beryllium content in a water-bearing stata. The beryllium transfer into solution is probably caused by increased fluorine content in water, which can assist in the formation of the $(\text{BeF})^+$ and BeF_2 compounds stable in water. The close paragenesis of the beryllium minerals and the fluorine minerals suggests that the aqueous halo with stable anomalous beryllium content should exist around beryllium deposits, especially if the helvite (easily oxidizing) is detected.

133.

Denham, A. H. and Webb, J. S.

Some geochemical anomalies in soil and stream

sediment related to beryl pegmatites in Rhodesia

and Uganda. INSTITUTION OF MINING AND

METALLURGY BULLETIN, no. 641, p. 329-344.

1960.

By using a rapid colorimetric test, beryllium anomalies up to 600 ft wide were detected in the near-surface horizon of residual soils overlying beryl pegmatites at several localities. Peak values are commonly 10-20 p.p.m. Beryllium, rising sharply to 80-125 p.p.m. immediately over the principal beryl zones, as compared to the background contents of 0.5-4 p.p.m. beryllium in normal soils derived from

133. (cont'd)

barren country rock. Similar, though more erratic, patterns of high values are detected by using a field beryllium monitor. Stream-sediment anomalies are also developed in those areas where the soil anomaly is being actively eroded, and in one area values of 4-10 p.p.m. beryllium compared to the local background of 1 p.p.m. beryllium extend for at least 3500 ft. down-stream from a previously unsuspected pegmatite deposit.

134.

Forbes, B. G.

Beryl deposits in South Australia. AUSTRALIA

(South) DEPARTMENT OF MINES. MINING

REVIEW, no. 108, p. 8-12. 1959.

Beryl which occurs in several pegmatites can be recovered only as a by-product.

135.

Forbes, B. G.

Beryl occurrences west of Boolcoomate Homestead.

AUSTRALIA (South) DEPARTMENT OF MINES.

MINING REVIEW, no. 108, p. 13-15. 1959.

136.

Gilkey, M. M.

HYATT RANCH PEGMATITE, LARIMER COUNTY,

WYOMING. U. S. Bureau of Mines, Report of

Investigations, no. 5643, 1960, 18p.

The deposit is of interest because of its beryl content. Total recorded production since 1936 is beryl 50 tons. Chemical and microscopic studies disclosed that beryl is potentially valuable. Tests were run on material from four diamond-drill holes. Hand sorting recovered 18% of the beryl. Two 7-ton samples assayed 0.065 and 0.22% beryllium oxide. The highest grade beryl concentrate obtained by flotation assayed only 4.5% beryllium oxide, and beryl recovery was only 45%.

137. Havens, R. , Nissen, W. I. and Rosenbaum, J. B.
FLOTATION OF BERTRANDITE AND PHENACITE
MT. WHEELER, NEVADA, BERYLLIUM ORE.
U. S. Bureau of Mines. Salt Lake City Metallurgy
Research Center, Utah. Report BM-RI-5875.
April 1961, 17p.

A flotation procedure was devised for beneficiating beryllium ores that contain beryllium minerals bertrandite and phenacite in a complex association with calcite, fluor-spar, mica, quartz, and other accessory minerals. Samples used in most of the research ranged from 0.49 to 0.73% beryllium oxide. Beryllium mineralization varied from two-thirds bertrandite to all phenacite. An unusually high grade sample containing 5% beryllium oxide as phenacite was floated on a batch basis to prepare concentrate for utilization studies. The beryllium minerals were floated from undeslimed pulps at natural pH using sodium fluoride and sodium hexametaphosphate (HMP), as modifiers, and a fatty-acid-fuel oil combination as the collector. Key factors were the use of a minimum of about 4 pounds of sodium fluoride and 2 to 4 pounds of HMP per ton of ore. Efficacy of the HMP was related to the grind, mineralogical composition, corollary reagents, and type and time of conditioning. Addition of the fluoride, HMP, and collector in that order, followed by appropriate conditioning after each addition, was essential for satisfactory flotation. A typical result obtained by bench-scale batch tests in a 500-gram cell on a bertrandite-phenacite sample of 0.4% beryllium oxide was 82% recovery in a concentrate of 14% beryllium oxide. Flotation of phenacite ore containing 5% beryllium oxide in a 10-kg cell resulted in an 85% recovery in a concentrate of 34% beryllium oxide.

138. Hiern, M. N.
Uranium-bearing pegmatite near Bimbowrie
Station. AUSTRALIA (South) DEPARTMENT
OF MINES. MINING REVIEW, no. 108, p. 66-68.
1959.

Beryl was found in pegmatite.

139. Hunt, E. C., Stanton, R. E. and Wells, R. A.
Field determination of beryllium in soils for
geochemical prospecting. INSTITUTION OF
MINING AND METALLURGY. BULLETIN no.
641, p. 361-369. 1960.

A new method is described for the determination of beryllium in soils. The procedure is rapid and sensitive. It is sufficiently accurate for prospecting purposes. The beryllium is selectively extracted by dilute HNO_3 after fusion of the sample with NH_4F . Interfering ions are sequestered with ethylenediaminetetraacetic acid and N, N-bis (2-hydroxy-ethyl) glycine, and the beryllium is extracted by visual comparison of colors after the addition of NaOH and Berillon. Soils containing from 0.5 to 50 p.p.m. beryllium can be analyzed without preliminary separation. The method has shown the existence of marked soil anomalies in the neighborhood of beryl pegmatites, in agreement with spectrographic findings.

140. Levinson, A. A.
Beryllium-fluorine mineralization at Aguachile
Mountain, Coahuila, Mexico. AMERICAN
MINERALOGIST v. 47, nos. 1 and 2, p. 67-74.
January - February 1962.

Bertrandite is found at the Aguachile Mountain fluoride deposit as the only beryllium mineral in a low temperature, low pressure hydrothermal environment. This type of occurrence plus a radial aggregate habit of slender crystals have not been previously reported for bertrandite. From a study of the mineralogy, paragenesis, petrology and geology of the deposit, it is believed that the beryllium is closely related to an alkali quartz microsyenite located in the center of Aguachile Mountain. This occurrence is another example of the association of beryllium minerals with fluorite and offers additional evidence for the importance of the beryllium-fluorine complex in nature.

141. Matsuo, S., Suzuki, S. and Yanagisawa, M.
Effects of a small amount of beryllium or lithium on aluminum-10 per cent magnesium alloy.
NAGOYA KOGYO GYUTSU SHIKENSHO HOKOKU,
v. 5, p. 603-606. 1956. (In Japanese)

The addition of 0.0005% of beryllium to Al-10 Mg alloy decreases the loss of Mg by oxidation at 800° for fifteen hours from 60 to about 5%.

142. Nekrasov, I. Ya.

A new type of beryllium mineralization.

GEOLOGIA RUDNYKH MESTORZHDENII,

no. 2, p. 32-43. 1960 (In Russian)

The study of beryllium genesis and geochemistry led to the conclusion that the massives of biotite and alaskite granites and subvolcanic bosses and dikes of quartzite porphyry and granite-porphyry situated usually in sheared zones at the boundary of two facies of a structural region are potentially beryllium bearers. The intersections of lateral fractures with regional crushed weakened zones are structurally the most favorable for the formation of beryllium-containing intrusives. Beryllium mineralization is usually located at the apexes of domelike protrusions in the granite massives. The most elevated zone of mineralization contains the highest amount of beryllium, which is usually ten times greater than the beryllium clarke. When the veins, bosses, or ore breccia are absent, beryllium is unevenly dispersed in the albitized and greisenized country rock, which in certain cases could be a beryllium ore. Small crystalline needle-shaped beryl, often unobserved by the naked eye, is the most characteristic. Therefore, during an exploration, attention should be given to the degree of pneumatolytic and hydrothermal alternation of granites and quartz and granite porphyry. The most favorable for beryllium mineralization are intensely albitized granites containing compounds of fluorine (fluorite and topaz), lithium (lithium muscovite, lepidolite, zinwaldite), and rare earths.

143. Rundkvist, D. V. and Chistyakov, N. E.

Beryl-fluorite-muscovite type of mineralization.

GEOLOGIA RUDNYKH MESTOROZHDENII,

no. 2, p. 44-52. 1960 (In Russian)

The beryl-fluorite-muscovite metasomatic mineralization is developed among the heterogeneous (carbonates and aluminosilicates) metamorphic rocks. The deposit is situated among the metamorphic argillaceous effusive and sedimentary rocks at the exocontact of the granite outcropping 5 km. from the deposit. Metamorphosed rocks consist of crystalline schists interbedded with epidote-albite-amphibolites. Two parallel tectonic zones control the location of mineralization which is of two types: wolframite-quartz veins, and beryl-fluorite-muscovite metasomatic formations, which is represented either by separate veinlets, nests and lenses or massive aggregates consisting entirely of muscovite and fluorite. For the fluorite-muscovite

regions, bandlike brecciated textures are characteristic; their development and origin depends on the structure of rocks on which they are developing. The country rocks greatly affected the mineral content of beryl-fluorite muscovite metasomatic formation. The most favorable for mineralization are the carbonaceous clayey schist and coal-like carbonated argillaceous schists. It was observed that, as a general rule, the greater the metamorphism of the country rocks the less favorable are conditions of mineralization. The reason for such selective replacement mineralization. The reason for such selective replacement mineralization is the change of solution alkalinity and oxidation-reduction conditions during the circulation of solution along the carbonate and carbonaceous argillite rocks.

144. Schilling, J. H.

Mineral resources of Tacos County, New Mexico.

NEW MEXICO BUREAU OF MINES AND MINERAL

RESOURCES. BULLETIN v. 71, p. 1-124. 1960

Mines and prospects are described. Beryl has been mined from pegmatities.

145. Schweisheimer, W.

Search for new beryllium sources. METALL

v. 15, p. 726-727. July 1961. (In German)

In exploration for beryllium utilization is made of its γ -induced neutron emission. The most common beryllium minerals are briefly discussed, and the various applications of the metal are reviewed.

146. Sorensen, H.

Beryllium minerals in a pegmatite in the nephe-

line syenites of Ilimaussaq, South West Greenland.

In INTERNATIONAL GEOLOGICAL CONGRESS,

COPENHAGEN, 1960. REPORT OF THE 21ST

SESSION. Pt. 17, p. 31-35. (In English)

Veins cutting nepheline syenites contain two beryllium silicates. One has ns α 1.548, β 1.550, γ 1.552, $2V$ 81° , positive; the second which replaces the first, is uniaxial, positive, ns ω 1.496 ± 0.001 , ℓ $1.502 - 0.002$; tetragonal with α 8.583, c 8.817 A.

It appears to be beryllium sodalite. Spectrographic analyses of other minerals of the area show low beryllium contents, the highest being steenstrupine with 50-100 p.p.m.

147. Urie, J. G.
The beryl-cassiterite bearing pegmatites of the
Sinceni area, Hlatikulu district, Swaziland.
SWAZILAND. ANNUAL REPORT OF THE GEO-
LOGICAL SURVEY AND MINES DEPARTMENT,
1959. p. 50-53.

Beryl is evident in large crystals.

OXIDES

148. Austerman, S. B. and Hopkins, A. R.
BERYLLIUM OXIDE SINGLE CRYSTAL GROWTH.
II. WATER VAPOR TRANSPORT METHOD.
Atomics International. Division of North American
Aviation, Inc., Canoga Park, Calif. REPORT
NAA-SR-6420. 15 Nov 1961. 20p. (Contract
AT911-1)-GEN-8).

Beryllium oxide single crystals were grown by a method employing a reversible reaction between beryllium oxide and water vapor at high temperature. The reaction product, $\text{Be}(\text{OH})_2$, was formed at temperatures between 1300 and 1650° C, then was allowed to decompose to beryllium oxide and water at a temperature several hundred degrees lower. Single crystals of simple and complex forms were formed. The principal interference with growth of large well-formed crystals was found to be impurities derived from the furnace, water, and the nutrient beryllium oxide placed in the furnace. Crystal growth mechanisms probably involved various types and orientations of dislocation structures, impurity poisoning of growth steps, spurious

148. (cont'd)

nucleation of new orientations by impurities, and diffusion-limited or -controlled nutrition of the growing crystals. By suitable control of purity of the crystal growth system, crystals of size 5 mm dia \times 1 mm thickness as platelets or 2 cm \times 2 mm diameter as rods were produced.

149.

Bennett, S. L. and Biermann, W. J.

Solubility of beryllium oxide in aqueous beryllium
sulphate solutions. CANADIAN JOURNAL OF
CHEMISTRY v. 40, no. 1, p. 73-77. Jan. 1962.

It is observed that ignited beryllium oxide was soluble in concentrated aqueous solutions of beryllium sulphate to the extent of 1 mole of oxide per two moles sulphate, saturation being virtually complete within six hours at 180° C. Since the molar solubility of aluminum oxide is much lower under similar conditions, it is suggested that partial resolution of oxide mixtures might be made on this basis.

150.

Blanco, R. E.

QUARTERLY PROGRESS REPORT FOR CHEMI-
CAL DEVELOPMENT SECTION B, APRIL-JUNE
1961. Oak Ridge National Laboratory, Tenn.
Report ORNL-TM-1. 15 Nov 1961, 92p. (Contract
(W-7405-Eng-26)).

Progress is reported on ... beryllium and beryllium oxide...

151. Coons, W. C.
CERAMOGRAPHIC STUDIES OF HOT-PRESSED
BERYLLIA. Curtis-Wright Corp., Research
Div., Quehanna, Penna. Report CWR-4052.
Dec 1959. 80p.

Improvements have been made in the ceramographic techniques employed in the preparation of specimens of hot-pressed beryllia for microscopic study. Because of the transparency of highly polished BeO crystals it has been possible, by the utilization of an oil immersion objective and bright field illumination, to examine materials to at least 0.011 mm below the plane of polish. Studies of polished surfaces before and after exposure in an oxidizing atmosphere at temperatures up to 2600° F have revealed heretofore unobserved changes in microstructure on hot-pressed beryllia. As a result of these new observations it is envisioned that correlations eventually may be found between the microstructural changes and subsequently determined variations in mechanical properties of beryllia components. Examinations were made of a miscellaneous group of samples which included samples having variations in color and grain size from top to bottom, hot-pressed weld joints of two compacts welded together, and hot-pressed compacts containing additions of MgO.

152. Hessinger, P. S.
Beryllia - engineered space age material.
INDUSTRIAL AND ENGINEERING CHEMISTRY,
v. 54, no. 3, p. 16-21. March 1962.

Adaptation of standard ceramic methods are bringing beryllia structures into reasonable cost ranges. A variety of applications are possible for the CPI.

153. Kothari, L. S. and Khubchandani, P. H.
Energy distribution of thermal neutrons in a
finite beryllium oxide assembly. JOURNAL OF
NUCLEAR ENERGY PARTS A AND B. REACTOR
SCIENCE AND TECHNOLOGY. v. 15, p. 30-31.
Sept 1961.

153. (cont'd)

The diffusion cooling constant C was calculated for thermal neutrons in beryllium oxide. The value obtained depended on the variation of the decay factor and on the form of neutron energy distribution assumed. Data are tabular and graphically represented, and comparison is made with previous data.

154.

Lannan, P. E.

Overcoming the heat and insulation rub; beryllia

cylinders. ELECTRONICS. v. 34, no. 28, p. 76,

78. 14 July 1961.

Beryllia cylinders have thermal conductivity greater than cast aluminum, very low loss tangent at microwave frequencies. Significance: cement cylinders into power transistors to operate at power rating required, forget weight and size hitch.

155.

Nishigaki, S.

BERYLLIUM OXIDE. Japanese Patent 9106(1959).

10 Oct 1959.

The dissolution of beryllium oxide in glacial AcOH forms basic beryllium acetate which is extracted by a solvent, such as CHCl_3 , CCl_4 , or C_6H_6 , to remove Fe, Al, Si, B, etc.

156.

Nishigaki, S.

BERYLLIUM OXIDE FROM BERYLLIUM-

CONTAINING ORES. Japanese Patent 10,902-

('59). 24 Dec. (In Japanese)

The recovery of beryllium oxide is by a cation-exchange-resin process.

157. Saulnier, A. and Mirand, P.

Determination of distribution of oxide in sintered
beryllium. ACADEMIE DES SCIENCES. COMPTES
RENDUS v. 250, no. 23, p. 3834-3835, 1960.

(In French)

Oxide was determined in two ways: extraction of oxide particles with C used to produce replica of the surface, and direct examination of thin sections. The latter technique has the advantage that dislocations of the metal are visible, and, in addition, it eliminates the continuous barrier of oxide at the grain boundaries.

158. Windecker, C. E.

How dangerous are beryllia ceramics?
ELECTRONICS v. 34, no. 41, p. 78-81.
13 Oct 1961.

Discussion illustrates how handling of toxic beryllium oxide ceramics can be done safely.

POWDER METALLURGY AND CASTING

159. Advanced forming techniques spur beryllium

usage. IRON AGE v. 188, p. 111-113.
14 Dec 1961.

Hot pressing of beryllium powder, extrusion of steel clad beryllium billets and Mn cored billets and forging of hot pressed beryllium for producing complex shapes and structural parts with improved mechanical properties. Evaluation of strength properties of forgings and billets.

160.

Fischer, R. B.

The magnitude of powder metallurgy. MINES

MAGAZINE v. 51, p. 21-22. Oct 1961.

Consideration of powder composition; particle size, shape and structure; amount of pressure applied; and process temperature. Pressing, sintering, slip casting, dispersion hardening and transpiration cooling processes for consolidating such powders as...Be.

161.

Jones, J. W. S. and Williams, J.

The preparation of beryllium-magnesium alloys

by powder-metallurgical methods. POWDER

METALLURGY v. 8, p. 37-41. 1961.

The preparation of alloys of beryllium and magnesium containing up to 20 wt.-% magnesium is described. Dense bodies may be prepared by infiltration of beryllium skeletons with molten magnesium or by liquid-phase sintering of cold-compacted mixed elemental powders. Such alloys consist of the appropriate element together with the compound $MgBe_{13}$, usually present as a continuous intergranular phase.

162.

Leszynsk, W.

Fourth international Plansee seminar (held in

Tyrol, Austria, on 20-24 June 1961) JOURNAL

OF METALS v. 13, p. 746-751. Oct 1961.

General subject of "Powder Metallurgy in the Nuclear Age" includes sintering theory, two-component systems, dispersion strengthening, reactor fuel materials, properties of uranium carbides and oxides, uranium nitride, boride and Tn, Pu and Be and surveys of high-melting metals including W, Ir, Mo, Ta, Cb and Ru and of pre-alloyed powders.

163. Limpany, B. B., Theodore, J. G. and Beaver, W. W.

FACTORS CONTROLLING THE SINTERING

CHARACTERISTICS OF BERYLLIUM POWDER.

Institute of Metals. Conference on Metallurgy
of Beryllium, London, 1961. Preprint no. 70.

1961. 8p.

The process variables that control the sinterability of unconsolidated beryllium powder were studied. Individual powder lots (-200 mesh) pressureless sintered at 1200° C at $< 10^{-2}$ mm Hg for five hours resulted in sintered d of 60-98% of theoretical. The influence on the sintering characteristics of particle shape, particle size and size distribution, specific surface, and variations in chemical purity was explored. Variations in iron contamination level were found to be the major cause of differences in the sintering characteristics.

164. Metal choice.

PRECISION METAL MOLDING v. 19, p. 43-54.

Oct 1961.

Castings and extrusion of bronze, nickel-brass, Al, Cu, Zn, beryllium copper, Mg, stainless steel, Ti and cobalt-brass alloys for applications utilizing the mechanical and physical properties of the materials.

165. Murray, P. and Livey, D. T.

IMPROVEMENTS IN OR RELATING TO THE

PRODUCTION OF SINTERED COMPACTS OF

BERYLLIA. British Patent 876,640. 6 Sept 1961.

A process is described for producing high-density sintered compacts from pure calcined beryllia powder. The process consists of cold-compacting a pure calcined beryllium oxide powder, heating the cold-compact to less than 1400° C. for a period such as to cause substantially all the particles to be welded together, and then heating gradually or in stages to a sintering temperature of at least 1500° C. For example, the cold-compacted powder may be heated for 12 hours at temperature between 1250 and 1400° C. before sintering to 1500° C.

166. New light alloys for die castings.

FONDERIA, v. 10, p. 360. Sept 1961. (In
Italian)

Aging and die casting of 364 Al alloy. Alloy is corrosion resistant and offers good castability. Effect of temperature and of Cr, Be, Fe and Mg content on tensile strength, elongation and ductility. Linear-dimensional tolerances of castings.

167. Olds, G. C. et al

HIGH-TEMPERATURE DUCTILITY OF POWDER-
FABRICATED BERYLLIUM AT HIGH AND LOW

STRAIN RATES. Associated Electrical Industries,

Ltd., Rugby and Manchester, England. Oct 1961. 5p.

The ductility of several batches of powder-fabricated, cross-rolled beryllium has been measured at a high strain rate of 10 percent/minute and low strain rates of 0.1 percent/hour or less, between room temperature and 700°C. Ductility/temperature curves showed maxima, dependent on strain rate, falling to low ductility at high temperatures. As strain rate decreased, the minimum in high-temperature ductility decreased; it fell to 2-3 percent at 600°C at 0.1 percent/hour, and rupture elongations below 1 percent were found at creep rates of the order of 0.001 percent/hour. Aluminum and possible other impurities appeared to contribute to high-temperature intergranular failure; an overaging heat treatment softened the material and improved high-temperature ductility at high strain rate, but had little effect at low strain rates, where it is believed that excessive grain-boundary impurities, such as oxide, limited the strain obtainable before cracking. A working-design creep stress for the material was under 1000 lb/in² at 600°C; both higher creep strength and ductility at high temperature should be obtainable in a cleaner material, with controlled alloying to increase grain-boundary strength.

168. Reeves, G. L. and Keeley, R. L.

THE PRESSURELESS SINTERING OF BERYL-
LIUM POWDER TO BILLETS FOR HOT

EXTRUSION. Tube Investments Technological

Centre, Walsall, Staffordshire, England. Oct

1961. 6p.

168. (cont'd)

The production of cylindrical and tubular billets is described and variables affecting packing density, sintered density, shrinkage, the cracking of hollows, and grain size have been investigated for two grades of powder. The densities of the billets sintered at 1200° C. for five hours for standard powder and at 1230° C. for 5 hours for high-purity powder, ranged from 72 to 98 percent of the theoretical value. Hot extrusion completed the consolidation of the powder.

PROCESSING

169.

Bort, C. I. and Moore, A.

GRAIN REFINEMENT OF INGOT SHEET BERYLLIUM BY WARM WORKING AND ANNEALING.

Gt. Brit. Atomic Weapons Research Establishment,
Aldermaston, Berkshire, England. Oct 1961. 4p.

The effect of warm working (below 700° C) on the subsequent annealing behavior of rolled-ingot beryllium sheet at high temperatures has been studied. With optimum working conditions and annealing conditions uniform and equiaxed, grain sizes of about 30 have been achieved which show about 12 percent elongation at 20° C. when tested in uniaxial tension.

170.

Bruin, H. J. de and Temple, R. B.

THE EXTRACTION OF BERYLLIUM BY
TRISOOCTYLAMINE IN THE PRESENCE OF
OXALATE ION. Australia. Atomic Energy
Commission Research Establishment, Lucas
Heights, New South Wales. Report AAEC/E-
68. July 1961, 17p.

Beryllium ions can be extracted into organic solvents by tertiary amines, in the presence of compounds which give rise to anionic complexes. The nature of the extracted species is investigated for the system beryllium/oxalate/trisooctylamine;

170. (cont'd)

it appears to be $\text{Be}(\text{C}_2\text{O}_4)_2(\text{NH}(\text{i-C}_8\text{H}_{15})_3)_2$. The beryllium/oxalate/water system is examined by the method of pH titration in the absence of the organic phase. Under the conditions chosen, the dissociation constants for oxalic acid are found to be $K_1 = 4.64 \times 10^{-2}$ and $K_2 = 1.20 \times 10^{-4}$, and the stability constants for the beryllium oxalate complexes $\beta_1 = 6.32 \times 10^3$ and $\beta_2 = 3.91 \times 10^5$.

171.

Bruin, H. J. de, Kairaitis, D. and Temple, R. B.

THE EXTRACTION OF BERYLLIUM BY

TRISOOCTYLAMINE. THE EFFECT OF THE

ANIONIC COMPLEXING AGENT. Australia.

Atomic Energy Commission Research Establish-

ment, Lucas Heights, New South Wales. Report

AAEC/E-77. Sept 1961. 16p.

The extraction of beryllium by triisooctylamine is measured over the pH range from 1 to 10, in the presence of malonic, maleic, succinic, phthalic, and salicylic acids. Values are obtained for the stability constants of the various metal-acid complexes by potentiometric titration. The degree of extraction is dependent on the abundance of the anionic complex present in the aqueous phase and this is in turn dependent on the strength of the corresponding acid and the stability of the complex.

172.

Bruin, H. J. de and Florence, T. M.

QUANTITATIVE STUDIES IN COMPLEX CHEM-

ISTRY. PART I. ELECTROMETRIC METHODS.

Australia. Atomic Energy Commission Research

Establishment, Lucas Heights, New South Wales.

Report AAEC/E-72. July 1961. 32p.

Methods for the determination of stability constants are considered with particular reference to the method of pH titration. Mathematical derivations proposed by several authors are discussed and rationalized by using a common symbolism. The

172. (cont'd)

use of acid association constants is advocated in preference to dissociation constants. The beryllium/oxyate system is used to illustrate the methods. Suggestions are made for the application of the fundamental data to problems in chemical processing and analytical chemistry.

173. Budnikov, P. P. and Avyagil'skii, A. A.

Sintering of beryllium oxide. OGNEUPORY

v. 26, no. 11, p. 525-530. Nov 1961. (In

Russian)

A study of the variation with temperature of beryllium oxide properties (shrinkage, water-holding capacity, volume weight, porosity, dynamics of weight losses, refractive index, crystal size, specific weight, and chemical resistance) has been made to determine the optimum conditions for the manufacture of dense ceramic objects from this compound. The following factors are recommended: (1) prefiring beryllium hydroxide in the range 1350 to 1500° C; (2) use of beryllium oxide of maximum specific weight; (3) preliminary grinding of prefired beryllium oxide to an average particle size of less than 2 to 3 μ ; (4) use of molding material of 20 to 30% is in the form of a hydroxide or low-temperature calcined oxide; (5) use of plasticizers such as paraffin wax, 7.5% starch solution or 5% solution of BeCl_2 to insure homogeneity of mass; (6) application of high specific molding pressure; and (7) prolonged exposure at final firing temperature for recrystallization.

174. Derham, L. J.

IMPROVEMENTS IN OR RELATING TO THE

PRODUCTION OF BERYLLIUM. British

Patent 878,390. 27 Sept 1961.

A process is described for producing beryllium by the reaction of beryllium fluoride with magnesium. In order to prepare the reactants magnesium particles such as raspings are mixed with ammonium beryllium fluoride. The mixture is briquetted, heated in a vacuum to remove ammonium fluoride gas, and subjected to pressure for densification. In the heating step, the briquettes are heated while in contact with a fusible salt (calcium chloride) formed from magnesium fluoride and the beryllium fluoride arises from an excess of the original ammonium beryllium fluoride.

175. Edwards, K. L. and Martin, A. J.
THE PURIFICATION OF BERYLLIUM BY
DISTILLATION AND ZONE MELTING.
Institute of Metals. Conference on Metal-
lurgy of Beryllium, London, 1961. Preprint
no. 47. 1961. 11p.

Apparatus is described for the purification of beryllium ingots by vacuum distillation and of extruded beryllium rods by zone refining. The two techniques are shown to differ a good deal in their complexity, in the extent of purification achieved, and in the type of product. Some mechanical tests for sheet rolled from distilled beryllium are included, but it is concluded that the degree of purification achieved by either technique must be increased considerably if significant improvements in the mechanical properties are to be realized.

176. Firsanova, L. A. and Belyaev, A. I.
Production of Be-Al-Cu alloys by reduction of
BeCl₂ vapor. IZVESTIYA VYSSHIKH UCHEBNIKH
ZAVEDENIY. TSVETNAYA METALLURGIYA, v. 2,
no. 1, p. 59-66. 1959. (In Russian)

Preparation of Be-Al-Cu alloy (\bar{I}) by reducing BeCl₂ vapor with Al-Mg and Cu-Mg alloys is shown to be superior to previously described reduction in the molten state. It permits the use of BeCl₂ containing beryllium oxide or other nonvolatile compounds, to work at 1000-1100° without too large loss of BeCl₂. Filtration of I permits the increase of its beryllium content up to 20%.

177. Greetham, G. and Martin, A. J.
THE EFFECT OF PURITY AND ORIENTATION
ON THE DEFORMATION OF BERYLLIUM SINGLE
CRYSTALS. Gt. Brit. Atomic Weapons Research
Establishment, Aldermaston, Berkshire, England.
Oct 1961. 6p.

Single crystals of beryllium have been prepared from extruded rods of vacuum-cast electrolytic ingot by a floating-zone technique. Two or more tensile specimens were prepared from these refined bars, in which the purity varied along the bar, and were tested at temperatures between -196 and 600° C. The results are discussed, and it is concluded from comparison with earlier work that further purification of beryllium could lead to a decrease in the ductile-brittle transition temperature for extruded rod.

178. Hill, N. A.
TEXTURES IN BERYLLIUM TUBES PRODUCED
FROM HOT-EXTRUDED ROD. Institute of Metals.
Conference on Metallurgy of Beryllium, London,
1961. Preprint no. 56. 1961. 8p.

The preferred orientations in beryllium tubes produced by warm (850° C) extrusion of billets machined from previously hot (1050° C)-extruded rod and flat are reported and compared with the textures in tubes extruded from randomly oriented, hot-pressed billets. In all the tubes there is a marked alignment of $\langle 10\bar{1}0 \rangle$ directions in the direction of extrusion, and the basal plane concentration vary only slightly and, in general, appear to be affected only by the conditions during the tube-extrusion stage.

179. Hooper, E. W. and Keen, N. J.
THE PURIFICATION OF BERYLLIUM BY A
DISTILLATION PROCESS. Gt. Brit. Atomic
Energy Research Establishment, Harwell,
England. Oct 1961. 5p.

179. (cont'd)

Commercial beryllium metal has been purified in gram quantities by a distillation process involving condensation in a heated tube, the temperature of which is graduated from 1300° C at the bottom to 800° C at the top. The interim results show that many of the impurities that are volatilized with beryllium pass to the cooler end of the condenser and the purest metal is collected in a zone in the temperature range 1100-1000° C. The anomalous behavior of certain impurities is described.

180. Jenkins, H. A. H. and Freeman, D. B.

COATING OF BERYLLIUM AND ITS ALLOYS.

British Patent 836,062. 1 June 1960.

Adherent coatings on beryllium and its alloys are formed by treating the surfaces with an acid aqueous solution. Common mineral acids and organic acids with a primary dissociation constant $>10^{-6}$ and certain accelerators may be used. It is believed that the coating is the result of the formation of a thin layer of solution saturated with beryllium at the surface. Beryllium may or may not be initially present in the solution.

181. Missel, L.

Chromic acid anodizing of beryllium-process

development. AMERICAN ELECTROPLATERS'

SOCIETY. PROCEEDINGS, v. 48, p. 109-111.

1916.

A method for preparing a jet black glossy anodic coating or a matte black anodic coating on beryllium has been described. The protection of the coating is independent on the surface condition. Anodic coatings materially increase corrosion resistance, paint adhesion and thermal radiation.

182. Moore, R. E., Shaffer, J. H. and McDuffie, H. F.
ORNL process gives ultra pure BeO. CHEMICAL
AND ENGINEERING NEWS v. 39, no. 44, p. 43.
30 Oct 1961.

A laboratory process for making beryllium oxide of very high purity has been worked out at Oak Ridge National Laboratory.

183. Nichkov, I. F. and Smirnov, M. V.
Electrolytic extraction of beryllium and zinc
at temperatures below 1000° C. IZVESTIYA
VYSSHIKH UCHEBNYKH ZAVEDENII - TSVETNAYA
METALLURGIYA v. 4, p. 105-107. March 1961.
(In Russian)

Interaction of beryllium and zinc at temperatures below 1000° C. in a closed electrolyzer with an electrolyte consisting of chlorides of Be, Ca and Na and Zn electrode.

184. O'Boyle, D.
Surface coatings for beryllium parts. MACHINE
DESIGN v. 33, p. 147-150. 21 Dec 1961.

Natural and anodic oxidation, electroplating, plating and flame spraying of beryllium parts to improve corrosion and wear resistance.

185. Paris, R.
New metals. CHIMIA v. 15, p. 443-449.
15 Sept 1961. (In French)

Preparation of Be, Ti, Zr, Ta and Nb from their ores. Densities, melting points and boiling points. Tensile strength and heat resistance of Ti alloys containing Al, Cr, Fe, Mn, Sn or V. Transformations in Ti. Ductility of Be as a function of temperature between 20-1000° C.

186. Pemsler, J. P. et al

THE PURIFICATION OF BERYLLIUM BY

DISTILLATION. Institute of Metals. Conference on Metallurgy of Beryllium, London, 1961.

Preprint no. 12. 1961. 6p.

Distillation was used to produce beryllium of very high purity to determine the relation between purity and mechanical properties of the metal. Purification is achieved by distillation from the melt in a beryllium oxide crucible heated to 1375° C. The distillate is condensed on a Ta collector heated by radiation from crucible to ~1090° C at the collector top and 1160° C at the bottom. Results indicate that metal impurities can be substantially removed in a single distillation. Iron, nickel, chromium and manganese contents are reduced to the 1-5 p.p.m. range. Mechanical properties of the material are being evaluated.

187. Perkins, G. D. and Willardson, R. K.

IMPURITIES IN ZONE-REFINED BERYLLIUM.

Institute of Metals. Conference on Metallurgy of Beryllium, London, 1961. Preprint no. 52.

1961. 12p.

A double-focusing mass spectrometer, utilizing a spark ionization source, was used to determine impurity concentration in zone-refined beryllium. The analyses indicate relatively large amounts of carbon and oxygen (~200 p.p.m.) in zone refined beryllium. Minor impurities include ~50 p.p.m. of iron, nickel, and beryllium hydride, 10 p.p.m. of copper, and <10 p.p.m. of silicon, calcium, sulphur, and nitrogen. The concentration of all other impurities is < 1 p.p.m. Zone refining is effective for many impurities, particularly aluminum, manganese, and beryllium hydride. The mass-spectrographic analysis is unusual in that it indicates the presence of compounds such as beryllium hydride, beryllium oxide and di-beryllium oxide.

188. Plaksin, I. N. and Solnyshkin, V. I.
The effect of caustic soda on beryllium mineral
surface when preparing it for flotation. IZVESTIYA
VYSSHIKH UCHEBNYKH ZAVEDENII - TSVETNAYA
METALLURGIYA v. 4, p. 28-35. March 1961.
(In Russian)

Use of infrared spectroscopy to study the surface structure of beryllium, rutile, ilmenite, Zr and magnetite ore particles treated by caustic soda and deposited on NaCl plates.

189. Sharples, J. T.
Electric heating for non-ferrous metals. METAL
INDUSTRY v. 99, p. 383-384. 10 Nov 1961.

Electron beam heating is applied to vacuum welding, zone refining, cold mold induction, vacuum induction melting and brazing. Use of electron beam melting in purification of ... beryllium...

190. Spangler, G. E., Arndt, E. J. and Herman, M.
PREPARATION AND EVALUATION OF HIGH
PURITY BERYLLIUM. Franklin Institute.
Laboratories for Research and Development.
Philadelphia, Penna. Bi-monthly progress
report 2 May to 1 July 1961. 14p. (Contract
NOW 61-0221-d)

The final assembly of the apparatus for zone melting one-inch beryllium rods was completed. In the initial trial of this apparatus, a stable zone was established and traversed in a cast bar. Four zone passes were made on this bar, resulting, after the fourth pass, in a single crystal one inch in diameter and four and one-half inches

190. (cont'd)

long. The melting of this bar resulted in a demonstration of several additional methods of purification accompanying vertical zone melting. A comparison of ductility in the polycrystalline beryllium with about 6% ductility in tension, the same material converted to a single crystal by one zone melting pass, and the multiply zone-refined single crystals which used the polycrystalline beryllium as starting material and exhibited up to 130% over-all elongation was attempted. It was discovered that one zone pass is effective in removing precipitates which appear to limit ductility and thus the one-pass single crystal cannot be compared to the polycrystalline material from which it was formed. The deformation sequence to failure was not identical to the multiply zone-refined crystal showing the greatest ductility and therefore the one-pass ductility result could not be compared to it. Stress-strain curves were plotted to determine the relative impurity effect on the deformation sequence in beryllium.

191.

Spangler, G. E. et al

PREPARATION AND EVALUATION OF HIGH

PURITY BERYLLIUM. Franklin Institute.

Laboratories for Research and Development,

Philadelphia, Penna. Bi-monthly progress

report no. 6, 2 Sept-1 Nov 1961. Report no.

P-A2476-6. 1 Nov 1961. 10p. (Contract

NOW61-0221-d) ASTIA AD-268 092.

The zone refining of one inch diameter Brush vacuum cast beryllium bar was continued, along with the zone refining of smaller diameter vacuum distilled and Pechiney SR grade bars. Three single crystal specimens of varying purity content were tested in tension. Vacuum distilled material which was subsequently zone melted seven passes exhibited a value of 400 psi for the critical resolved shear stress on the basal plane. Additional zone melted polycrystalline was prepared by hot rolling and recrystallizing four pass single crystal beryllium. Two different orientations with respect to the rolling plane were used. Tensile tests and bend tests were performed, but the results to date are inconclusive. Preliminary examinations have been made of zone refined beryllium by electron transmission microscopy.

192. Tatman, M.
Processing beryllium. AIRCRAFT PRODUCTION,
v. 23, no. 12, p. 466-470. Dec 1961.

Beryllium is a promising material for missiles and spacecraft because of its high strength, low-density, high melting point, high thermal conductivity and high specific heat. It is, however, extremely toxic. Some of the methods of machining, joining, extruding, and pressing the material are described.

193. Vil'komirskii, I. E. et al
Production of high purity beryllium (USSR).
ATOMNAIA ENERGIIA v. 11, no. 3, p. 233-239.
Sept 1961. (In Russian)

High-purity beryllium has been produced on an industrial scale by the chlorination of BeO with CCl_4 and electrolysis of the BeCl_2 produced, mixed with NaCl, at 320 to 340° C. In laboratory-scale chlorination of BeO containing no more than 0.006% impurities, the optimum temperature was found to be 650 to 700° C and the optimum feed rate of CCl_4 , 25 g/min. Nickel and nickel-base alloys were found to be the best materials for condensers operating in a Cl- BeCl_2 - CCl_4 atmosphere at temperatures no higher than 300° C. The BeCl_2 produced contained 0.005 to 0.045% impurities and 0.01 to 0.1% water-insoluble residues. In the experimental industrial production of 25 tons of BeCl_2 , the consumption of CCl_4 was 1.6 kg per kg of BeCl_2 ; the degree of BeCl_2 condensation was 97.8%; the direct extraction of BeCl_2 was 85%, and with reprocessing of wastes reached 96%. Initially, the electrolysis of the BeCl_2 -NaCl mixture was accomplished with nickel cathodes; subsequently, graphite cathodes were used, with a cathodic current density of 6.5 to 7.5 a/dm². The purity of the electrolytic beryllium was 99.937 to 99.966%. This simple, comparatively safe, and economical method was employed in the production of several tons of beryllium pure enough for atomic industry applications.

194. Whitby, L., Gowen, E. and Levy, D. J.
Chromic acid anodizing of beryllium: Process
parameter. AMERICAN ELECTROPLATERS'
SOCIETY. PROCEEDINGS v. 48, p. 106-108.
1961.

194. (cont'd)

Adherent glossy-black films of beryllium oxide are formed when beryllium is anodized in at least 10% w/v CrO. The anodic reaction is independent of current density. Powdery, non-adherent coatings develop at elevated temperature. The film has little porosity. Thinner-films may be less dense. The process is inefficient and only 7% of the power consumed is utilized in forming the coating.

195.

Zeppelin, H. von

SEPARATION OF MAGNESIUM CHLORIDE AND
CALCIUM CHLORIDE FROM TITANIUM, ZIR-
CONIUM AND BERYLLIUM POWDER. German

Patent no. 1, 029, 166. 30 Apr 1958. (In German)

The $MgCl_2$ and $CaCl_2$ contained in Be powder formed from $BeCl_2$ by reduction with Mg or Ca are extracted with EtOH or ethylene glycol. The contamination of the metal, e. g. by O, taking place on extraction by aqueous solvents is avoided by this procedure.

PROPERTIES

196.

Alexander, W. K.

SPECIFICATION FOR PROCUREMENT OF ZIR-
CONIUM-BERYLLIUM BRAZING ALLOY. Hanford
Atomic Products Operation, Richland, Wash.
Report HW-69715. 23 May 1961. 3p. (Contract
AT (45-1)-1350)

A specification is presented for guidance in procurement of Zr-5 wt % Be preformed brazing alloy shapes.

197. Allen, B. and Moore, A.
THE TOUGH → BRITTLE TRANSITION IN
BERYLLIUM. Institute of Metals. Conference
on Metallurgy of Beryllium, London 1961. Pre-
print No. 46. 1961. 15p.

The sudden change in the level of ductility and the fracture mode in commercially pure beryllium, tested in tension between 20 and ~ 200° C, is analysed for rolled and extruded samples of polycrystalline ingot beryllium, in terms of mechanisms proposed for a tough → brittle transition. General indications are that the critical temperature, T_c , would be ~ 20° C for material of uniform and uniaxial grain-size of ~ 1-10 μ diameter, and that ~ 10% elongation would be obtained at sub-critical temperature. The experimental data are, however, insufficient to enable a critical analysis in terms of either the Stroh, Cottrell, or Petch models of a tough → brittle transition to be made, but it is concluded from metallographic and tensile data that, under certain conditions, fracture is associated with bend plane splitting.

198. Austerman, S. B.
DECREPITATION OF BERYLLIUM OXIDE AT
HIGH TEMPERATURE. Atomics International,
Div. of North American Aviation Inc., Canoga
Park, Calif. Report NAA-SR-6428. 30 Sept 1961.
11p. (Contract AT(11-1)-GEN-8)

Changes in physical and geometrical appearance and in microstructure are described. An order-disorder phenomenon couples with dislocation rearrangement is suggested as the mechanism of decrepitation.

199. Austerman, S. B., Meyer, R. A. and Swarthout, D. G.

OXYGEN DIFFUSION IN BERYLLIUM OXIDE.

Atomics International. Div. of North American

Aviation, Inc., Canoga Park, Calif. Report

NAA-SR-6427. 15 Sept 1961. 24p. (Contract

AT-11-1-GEN-8)

Polycrystalline BeO diffusion samples were prepared with a surface layer of BeO¹⁸. The samples were annealed at 1600 to 1900° C. to allow the O¹⁸ to diffuse inward. The samples were analyzed by a sectioning technique, with determination of the O¹⁸/O¹⁶ ratio by vacuum fusion and mass spectrometric methods. The O¹⁸ concentration profile revealed two (and possible three) data regions, indicating a complex oxygen diffusion process in BeO. Comparison of net O¹⁸ diffusion transport with beryllium transport in nearly identical samples indicates O to be several orders of magnitude slower, in partial qualitative agreement with recent data on sintering kinetics of BeO powder.

200. Bennett, W. D. G. and Sumner, G.

SOME CREEP AND STRESS-RUPTURE PROP-

ERTIES OF SINTERED AND EXTRUDED BERYL-

LIUM. Institute of Metals. Conference on Metal-

lurgy of Beryllium, London 1961. Preprint No.

61. 1961. 5p.

The stress-rupture behavior of loose-sintered and warm-extruded beryllium was investigated in the range 400-650° C with test durations of up to 10,000 h. An investigation of the creep behavior of hot-pressed beryllium is reported. Specimens taken from the direction of pressing and the transverse direction show little difference in their creep behavior. An equation of the type $E = k_1 \sigma^n \exp(k_2/T)$ describes the creep behavior of beryllium fabricated by powder routes with reasonable accuracy.

201. Booker, J., Paine, R.M. and Stonehouse, A.J.

INVESTIGATION OF REFRACTORY METAL
BERYLLIDES AND SILICIDES AS VERY HIGH
TEMPERATURE MATERIALS. Brush Beryl-
lium Co., Cleveland, Ohio. Progress report
no. 7, 1 April 1961 - 30 June 1961. Technical
report no. 22 3-222. 15 July 1961. 27p.
(Contract AF 33(616)-6540)

The investigation of refractory metal beryllides and silicides for very high tempera-
ture ($> 2500^{\circ}$ F) applications for short-time use, 10 hours or less, was continued.
Some of the properties of Ta_2Be_{17} and WSi_2 as a function of stoichiometry, particu-
larly in the intermediate temperature region, are reported and discussed. Tests
included modulus of rupture, thermal shock, and oxidation resistance measurements.
The first of a series of vapor pressure measurements on selected beryllides using a
direct weighing Knudsen cell technique is reported for $ZrBe_{13}$. Also a preliminary
analysis of Zr_2Be_{17} oxide scales for products is reported.

202. Bunce, J. E. J. and Evans, R. E.

A STUDY OF THE EFFECT OF GRAIN-SIZE,
TEXTURE, AND ANNEALING TREATMENT
ON THE PROPERTIES OF WROUGHT BERYLLIUM
INGOT. Institute of Metals. Conference
on Metallurgy of Beryllium, London 1961.
Preprint no. 45. 1961. 16p.

Beryllium sheets of varying grain-size, but of comparable texture, were evaluated
for mechanical properties over the range $25-600^{\circ}$ C. A lowering of the brittle \rightarrow
ductile transition temperature, and a general improvement of properties over the
whole temperature range was observed with decrease in grain-size. The combined
effects of texture, heat-treatment, and purity were evaluated by comparing the
transverse and longitudinal properties of extrusions, in an effort to establish which
of these variables has the greatest influence on the tensile properties of beryllium
at high temperature.

203. Chang, R. and Graham, L. G.
TRANSIENT CREEP AND ASSOCIATED GRAIN-
BOUNDARY PHENOMENA IN POLYCRYSTALLINE
ALUMINA AND BERYLLIA. Atomics International,
Div. of North American Aviation, Inc., Canoga
Park, Calif. Report NAA-SR-6483. 30 Sept 1961.
44p. (Contract AT(11-1)-GEN-8)

The importance of, and the interrelation between, transient creep and grain-boundary phenomena in polycrystalline alumina and beryllia are discussed. It is found that the transient creep strain in these materials follows the relationship $\Sigma \cong \alpha(t/\tau)^m$, where α is a constant dependent on the applied stress, t is X time, τ is a time constant related to temperature by the Arrhenius equation $\tau = \tau_0[\exp(Q/RT)]$, and m is an exponent of the order of 2/3 to 1/3. Except for the initial stage of transient creep, m varies usually between 0.3 and 0.4 and Q is an activation energy almost equal to that for self-diffusion. During the initial stage of transient creep, m is considerably larger and the activation energy Q considerably smaller. A new mechanism, combining grain-boundary motion and diffusion-controlled stress relaxation along grain boundaries and at grain corners, is proposed to explain the difference in tensile and compression creep behavior of high density polycrystalline alumina and beryllia.

204. Crossley, F. A. and Van Thyne, R. J.
DUCTILE BERYLLIUM COMPOSITES BY LIQUID-
PHASE SINTERING. Armour Research Foundation,
Chicago, Ill. Oct 1961. 6p.

Liquid-phase sintering to produce an envelope-type microstructure has shown considerable promise for producing ductile beryllium composites. Composites containing aluminum or silver as the matrix, ternary additions for promoting sinterability, and quaternary additions for strengthening the matrix have been investigated. The best results were obtained with a pressure-sintered compact of the system beryllium-silver-aluminum-germanium. This compact tested in uniaxial compression had properties as follows: 0.2 percent proof stress 52,400 lb/in², true stress at initiation of cracking at the surface 97,000 lb/in² (engineering stress of 130,000 lb/in²), total plastic deformation at crack initiation 22 percent and modulus of elasticity 22×10^6 lb/in. The matrix content of this material was calculated from the density to be about 3 percent by volume. Density of 2.07 g/cc gives a modulus: density ratio of this compact 2.9 times that of steel.

205. Doyle, W. P.
Optical absorption of some oxides in the
Schumann ultra-violet region. BRITISH
JOURNAL OF APPLIED PHYSICS. v. 12,
p. 574-576. Oct 1961.

Optical absorption in thin films of stannous oxide, stannic oxide, lead monoxide, and the trioxides of arsenic, antimony and bismuth, beryllium oxide, zirconium dioxide and tantalum pentoxide is measured in the energy range 4 to 10.5 ev.

206. Eichelberger, J. F. et al
PHASE EQUILIBRIA IN THE NaF-BeF₂-UF₄
TERNARY FUSED SALT SYSTEM. Mound Labor-
atory, Miamisburg, Ohio. Report MLM-1081.
(1960?) 62p. (Contract AT(33-1)-GEN-53)

The phase equilibrium diagram presented for the ternary fused-salt system NaF-BeF₂-UF₄ is based on evidence from differential thermal analysis, polarizing light microscopy, and x-ray examination of small samples obtained from thermal gradient quenching experiments, and from high-temperature filtration experiments. All the stable compounds in the binary systems NaF-BeF₂ and NaF-UF₄ displayed primary phase fields in the ternary system, including a new subsolidus compound which was observed and tentatively assigned the formula NaF-4UF₄. No ternary compounds or solid solutions were formed. The following three eutectics were found in the ternary system: 72.5 (mole %) NaF-17.0 BeF₂-10.5 UF₄, 485° C; 56.0 (mole %) NaF-43.5 BeF₂-0.5 UF₄, 339° C; and 43.5 (mole %) NaF-56.0 BeF₂-0.5 UF₄, 350° C.

207. Ells, C. F. and Evans, W.
THE BEHAVIOR OF HYDROGEN IN BERYLLIUM.
Atomic Energy of Canada, Ltd., Chalk River,
Ontario. Report CRGM-1041. Aug 1961. 11p.

Hydrogen has been introduced into samples of several types of beryllium by proton irradiation, and the subsequent behavior of the hydrogen on post-irradiation heating of the samples has been observed by metallographic techniques. The materials used had beryllium oxide contents of 0.1 to 2.2 wt%; the hydrogen content studied

207. (cont'd)

was approximately $0.5 \text{ cm}^3 \text{ gas/sm}^3 \text{ metal}$. Agglomerates of hydrogen were seen after heating for one hour at temperatures as low as 320° C . Grain boundaries were highly preferred points of nucleation for the agglomerates, and after a sufficiently severe heat treatment, e.g., 1 hour at 1000° C , extensive grain boundary cracking was observed in most of the materials studied. The results can be interpreted qualitatively in terms of observations from other gas metal systems; in particular the behavior of hydrogen in beryllium is very similar to its behavior in aluminum.

208. Eremanenko, V. N., Nizhenko, V. I. and Naidich, Y. V.

Surface tension of certain intermetallic alloys.

AKADEMIYA NAUK SSSR. IZVESTIYA. OTDELENIE

TEKHNICHESKIKH NAUK. METALLURGIYA I

TOPLIVO^o p. 150-154. March 1961. (In Russian)

Isothermic curves are established for surface tension and density of Cu-Al, Ni-Al and Ni-Be alloy systems at 1640° C . by the falling drop method.

209. Garber, R. L., Gindin, I. A. and Shubin, Yu. V.

Extension of beryllium monocrystals in the

temperature range $20-500^\circ \text{ C}$. PHYSICS OF METALS

AND METALLOGRAPHY, v. 12, no. 3, p. 121-128.

1961.

A study has been made of the mechanical properties, and elements of ductility and fracture of monocrystals of beryllium (99.9 per cent) in tension in the temperature range $20-500^\circ \text{ C}$. The orientation of the specimens was appropriate for an arrangement of the basal plane (0001) at an angle of 45° to the axis of tension.

210. Garber, R. I. , Gindin, I. A. and Shubin, Yu. V.
Orientation dependence of the slip and failure of
beryllium single crystals in tension. SOVIET
PHYSICS-SOLID STATE v. 3, no. 4, p. 832-837.
Oct 1961.

Study of mechanical properties and crystallographic elements of plasticity and failure at 20° C. with determination of critical shear, fracture stresses and relative elongation. Resultant data agree with rule of constancy of normal and shear stresses in brittle fractures.

211. Gasc, C.
A STUDY OF MECHANICAL ANISOTROPY AND
HETEROGENEITY IN BERYLLIUM SHEETS.
Laboratoire de Metallurgie Physique, Poitiers,
France. Oct 1961, 4p.

Considerable and varied experience has made it possible to review some of the aspects of the brittleness of beryllium at room temperature. Studies of preferred orientation by means of pole figures, supplemented by tensile tests, have shown that, with polycrystalline metal, heavy plastic deformation is possible only by certain modes of slip, requiring special textures. Again, the scatter in tensile-test results must derive from the marked structural inhomogeneity of the sheets. The latter is due, in particular, to the various processes of recrystallization, which are practically unexplored in this metal. The effect of impurities is of great importance, and appears to depend on the size and distribution of impurity constituents, which themselves depend on earlier thermal treatments.

212. Gaylord, E. W. and Shu, H.

Coefficients of static friction under statically
and dynamically applied loads. WEAR v. 4,
p. 401-412. Sept-Oct 1961.

Determination of effects of load, sliding and slipping under 10,000 and 20,000 psi.
for combination of steel rubbing on steel, Ti on steel, U on U, Ti on U, Be on U and
Be on Ti.

213. Gelles, S. H. et al

THE STABILITY OF THE HIGH-TEMPERATURE
PHASE IN BERYLLIUM AND BERYLLIUM ALLOYS.
Nuclear Metals Inc., Concord, Mass. Oct 1961. 7p.
(Contract No. AT(30-1)-1565)

An investigation is in progress to determine the stability and mechanical properties
of the body-centered cubic phase that exists just below the melting point of beryllium-
rich alloys. Differential thermal analysis (DTA) has been applied to alloys of beryl-
lium in each of the following systems: barium, cerium, chromium, cobalt, copper,
iron, lanthanum, manganese, nickel, niobium, palladium, platinum, silicon, silver,
vanadium, zirconium, nickel--cobalt, nickel--copper, nickel--iron, nickel--palladium,
nickel--cobalt--iron, and nickel--cobalt--manganese. The DTA has established
fairly well the β -phase field in the systems of beryllium with chromium, cobalt,
copper, and nickel; tentative β -phase fields have been constructed for the systems of
beryllium with iron, manganese, silicon, and silver. The remaining systems are
still being studied.

214. General Electric Co. Flight Propulsion Labora-
tory Department, Cincinnati, Ohio.

HIGH TEMPERATURE MATERIALS PROGRAM
PROGRESS REPORT NO. 3, PART A, 1 JULY 1961-
AUGUST 1961. Report GEMP-3A. 15 Sept 1961.
35p. (Contract AT(940-1)-2847)

214. (cont'd)

Progress is reported on the following material development programs: metallic fuel element materials for greater than 1200° C operation in oxidizing atmospheres, high-temperature control materials, fabricability of high-temperature structural materials, effect of radiation on high-temperature alloys, moderator fabrication and testing, and high-temperature thermal-insulation development.

215. General Electric Co. Flight Propulsion Laboratory Department, Cincinnati, Ohio.

HIGH TEMPERATURE MATERIALS PROGRAM.

Progress Report No. 4, Part A, 1 Aug 1961 -

30 Sept 1961. Report GEMP-4A. 15 Oct 1961.

15p. (Contract AT(40-1)-2847)

Samples of two compositions of BeO plus MgO were placed in the Engineering Test Reactor. Designs for cartridges to be used in 600 and 1000° C irradiations were completed. Sintering conditions were established for preparing rods of the remaining four of the six BeO compositions to be tested. A more precise method of measuring grain size was adopted. Physical property measurements consisted largely of non-destructive tests on both control and irradiation specimens.

216. Gienza, C. J.

EFFECT OF PROCESS VARIABLES ON THE
BRITTLE BEHAVIOR OF BERYLLIUM SHEET.

The Martin Co., Baltimore, Md. Oct 1961. 5p.

(Contract AF 33(600)-40648).

Beryllium sheets, produced by three techniques, (hot-pressed, hot cross-rolled and hot-upset) were subjected to various mechanical tests. Conventional tests, i.e., tension, compression, and notch tension, did not provide an adequate index of the brittleness as it relates to crystallographic texture, process variables, and size-effect. A clearer characterization of the relative mechanical behavior of the beryllium sheets was indicated from the results of constant-moment bend-ductility tests. Bend-test specimens of varying width and thickness were employed to establish

216. (cont'd)

quantitatively the plastic strain behavior of the test materials as a function size. In general, the ductile failure of beryllium sheet in ending was related to the strain-hardening rate in tension. A forged-upset sheet exhibited good ductile hardening rate in tension. A forged-upset sheet exhibited good ductile behavior in bending, similar to an isotropic hot-pressed sheet, and relatively high-mechanical properties values equal to those of a hot cross-rolled sheet. The results also indicated that the ductile behavior of beryllium sheet depends on: (1) the degree of anisotropy developed by reduction during hot working, (2) the stress state, and (3) to a large extent on the temperature employed during reduction.

217. Guest, J. C. and Hudson, M. J.

TENSILE PROPERTIES OF HOT-EXTRUDED

BERYLLIUM ROD AND TUBING. Tube Investments Technological Centre, Walsall, Staffordshire, England. Oct 1961, 5p.

Tensile properties of beryllium rod and tubing produced by hot extrusion of powder material have been determined over the temperature range 15-700° C. Both longitudinal and transverse data were obtained on tubing, the latter being markedly inferior. Texture determinations show that this anisotropy results from preferred orientation developed in extrusion. A limited investigation of heat treatments results in considerable improvements in ductility being obtained over the range 300-700° C.

218. Hausner, H. H.

PROPERTIES OF BERYLLIUM. General Astro-metals Corp., Yonkers, N.Y. Oct 1961. 17p.

The 24 tables included represent the best available data on the structure, the physical, mechanical, and chemical properties of beryllium. This compilation of beryllium data represents a first attempt to give the designer in the fields of aircraft, missiles, and nuclear engineering as much information for his calculations as possible. It is intended to extend these data in the future, as knowledge concerning beryllium progresses, and to bring these data up to date from time to time.

219.

Herman, M. and Spangler, G. E.

THE FLOW AND FRACTURE CHARACTERISTICS
OF ZONE-MELTED BERYLLIUM. Franklin

Institute, Philadelphia, Penna. Oct 1961. 7p.

The purpose of this investigation was to determine whether an "impurity effect" was associated with the basal plane ductility of beryllium. Floating-zone-type zone-melting procedures were used both to purify and produce beryllium single crystals. These crystals were tested in tension with their orientation arranged to yield basal plane slip. The critical resolved shear stress was observed to vary from 2400 to 500 lb/in², decreasing with increased purification. The glide strain varied from 16 to 220 percent, increasing with increased purification. It was concluded that an "impurity effect" exists. The effect of impurities and testing conditions on the ductility of beryllium, together with the manner in which zone melting affected impurity removal, is discussed.

220.

Hill, N. A.

THE EFFECT OF VARIOUS TREATMENTS UPON
THE TENSILE PROPERTIES OF A BERYLLIUM

SHEET. Institute of Metals. Conference on
Metallurgy of Beryllium, London, 1961. Pre-
print no. 62. 1961. 9p.

The room temperature tensile properties of a beryllium sheet depend upon the method of preparation of the test-piece. Fifteen specimens, tested as-machined, fractured at stresses around a mean of 23 tons/in² with elongations about a mean of 0.4%. Annealing, etching, and a combination of the two treatments raised the mean values to ~35 tons/in² and 11-22%, respectively, for groups of fifteen specimens. Etching 0.008 inches from the surface reduced the mean 0.2% PS to 19.7 tons/in², from the mean value of 22.5 tons/in² obtained from specimens after grinding, annealing, etching to remove 0.011 inches of surface, and combined annealing and etching. Statistical analysis shows that this difference is outside the range of random scatter and it is attributed to the presence of residual stresses from machining operations.

221. Hollis, W. S.
Crystal filaments. PRODUCTION ENGINEER
v. 40, p. 611-661. Sept 1961.

Growth mechanisms for crystal filaments of pure single crystal and metal whiskers (Fe, Cu, Be, Si, Sn, W, Ag, Cd, Zn) are explained by the presence of irregularities in the atomic structure of dislocations. Stress-strain patterns and relative strength of filament and bulk materials are given.

222. Hughel, T. J.
AN INVESTIGATION OF THE PRECISION MECHANICAL PROPERTIES OF SEVERAL TYPES OF BERYLLIUM. Institute of Metals. Conference on Metallurgy of Beryllium, London 1961. Preprint
no. 24. 1961. 7p.

The mechanical properties of beryllium that are important in gyro application are discussed. Methods for the measurement of the precision elastic limit and dimensional stability of beryllium are described. Results of the measurement of these properties on six modified forms of beryllium are given. It is shown that fine grain-size and high beryllium oxide content favor high precision elastic limit and good dimensional stability. It is also shown that the addition of 1% iron as an alloying element improves the precision mechanical properties of beryllium without significantly altering the diamagnetic character. The variability of the precision elastic limit of standard-production beryllium is rather large, both within a single pressing and from block to block.

223. Lampson, F. K.
THE ELECTRICAL PROPERTIES OF ARMCO IRON AND BERYLLIUM. Fairchild Engine and Airplane Corp., Nepa Division, Oak Ridge, Tenn.
Summary report. NEPA-1860. 4 May 1951. 9p.
PB140790.

223. (cont'd)

The electrical resistivity of Armco Iron and beryllium has been determined over a wide range of temperatures. The beryllium investigation was conducted in both purified helium and in vacuo, while iron was checked solely in a helium atmosphere.. The resistivity of beryllium metal (Brush grade QM-V) is reported from room temperature to 2000° F. The resistivity-temperature relation is linear from room temperature to 1400° F; thereafter, the resistivity increases rapidly with a subsequent increase in temperature. No phase change occurs in the beryllium through the temperature range of this investigation.

224. Lockheed Aircraft Corp. Missiles and Space
Division, Sunnyvale, Calif.
LMSD BERYLLIUM EVALUATION PROGRAM.
Report LMSD-800257. 15 Oct 1960, 23p. (Contract NOrd 17017)

A catalog of all Polaris Missile System-sponsored and -directed evaluations on beryllium up to but excluding the fabrication development phase is presented. The scope and nature of each test or evaluation is described.

225. Martin, A. J. and Ellis, G. C.
THE DUCTILITY PROBLEM IN BERYLLIUM.
Institute of Metals. Conference on Metallurgy
of Beryllium, London 1961. Preprint no. 48.
1961. 21p.

A survey is made of the factors that may contribute to the lack of ductility in beryllium both at room temperature and at higher temperature. The influence of strain rate, grain-size, purity, and crystallographic texture is discussed. The behavior of beryllium between 25 and 250° C is described in terms of brittle → tough transition, and it is concluded that purification, grain refinement, and a partial randomization of texture are the main studies that should be pursued. The decreased ductility at ~600° C is ascribed to impurities present in metastable solution, and an argument is presented that either purification, or alloying followed by heat-treatment, should increase the high-temperature ductility.

226. Meredith, J. E. and Sawkill, J.
A PRECIPITATION REACTION IN COMMER-
CIALLY PURE BERYLLIUM. Tube Investments
Research Laboratories, Hinxton Hall, Cambridge,
England. Oct 1961. 5p.

Using dilute aqueous copper sulfate solution as an etchant, a series of microstructures has been obtained from the heat treatment of hot-extruded cast ingot beryllium that is indicative of a precipitation reaction. Hot-extruded metal is a supersaturated solid solution, and the solute may be precipitated by aging in the temperature range 550-750° C. The precipitation is localized initially at grain boundaries and around inclusions within the grains. This is followed by general precipitation and over-aging at the boundaries. Resolution takes place at 850° C, and the sequence of precipitation may be repeated. It is proposed that initial precipitation occurs at boundaries because they act as vacancy sources. Electron-probe micro-analysis has shown that iron is involved in the reaction. Tensile tests have been made over the range 20-600° C. on as-extruded metal and after aging. Aging results in substantial increases in tensile elongation above 200° C. It is suggested that iron in solution limits high-temperature ductility. The removal of iron from solution by precipitation leads to higher elongations. After aging, the fracture in the range 20-200° C. is mainly intergranular.

227. Moore, A. et al
PRECIPITATION-AGEING AND IMPROVED
MECHANICAL PROPERTIES IN COMMER-
CIALLY PURE BERYLLIUM AND BERYLLIUM
ALLOYS. Institute of Metals. Conference on
Metallurgy of Beryllium, London 1961. Pre-
print No. 44. 1961. 15p.

The effect of small addition of iron and of binary addition of aluminum, silicon, and nickel on the tensile properties of beryllium near 600° C were determined on extruded ingot metal as a function of annealing schedules over the range 500-1000° C. It is shown that the normal ductility minimum found at 600° C is associated with an "aged" condition that can be remedied by "overaging", when ductilities as high as 75% at 600° C are observed. Corresponding changes in the constitution are evident from optics and electron microscopy and x-ray diffraction techniques, as well as micro-beam analyses.

228. 1961 metal selector.

STEEL, v. 149, p. 115-116. 16 Oct 1961.

Composition, physical and mechanical properties and applications are tabulated for refractory, high temperature, cast high, spring, Cu, Be, Al, Ti, Mg, Zn, and Zr alloys, stainless, heat resistant, H, alloy, high strength and super-strength steels and ferrous castings.

229. Nuclear Metals, Inc., Concord, Mass.

FUNDAMENTAL AND APPLIED RESEARCH
AND DEVELOPMENT IN METALLURGY.

Progress Report to the United States Atomic

Energy Commission for July 1961. Report

NMI-2097. 25 Oct 1961. 24p. (Contract

AT(930-1)-1565)

Developments are discussed for evaluations of the fundamentals of single crystal deformation in zone-refined beryllium.

230. Pickett, J.J., Levine, E.D. and Nowak, W.B.

FUNDAMENTAL AND APPLIED RESEARCH
AND DEVELOPMENT IN METALLURGY;

STABILITY OF THE HIGH TEMPERATURE

BETA PHASE IN BERYLLIUM AND BERYL-

LIUM ALLOYS. Nuclear Metals, Inc., Concord,

Mass. Report NMI-1252. 11 Sept 1961. 34p.

(Contract No. AT(30-1)-1565)

The discovery of a high-temperature phase in beryllium opened a new field in beryllium metallurgy. Studies in this field were carried out over the past year. Differential thermal analysis (DTA) to determine equilibrium phase boundaries was applied

230. (cont'd)

to alloys of beryllium in each of the following systems: Ba, Ce, Co, Cu, La, Mn, Pt, Ag, Ni-Co, Ni-Fe, Ni-Cu, Ni-Co-Fe, and Ni-Co-Mn. The boundaries of the beta beryllium regions in the systems Be-Co and Be-Cu were fairly well established; the remaining systems require further study using additional test methods. The Be-Ni system, studied previously, and the Be-Co and Be-Cu systems enlarge the beta field and lower the beta-to-alpha transus temperatures and electron-to-atom ratios for alloys of beryllium with Co, Cu, Fe, and Ni. Application of this relationship to ternary and quaternary alloys met with some success. On the basis of a few tests, the beta phase structure appears to be more ductile than the alpha phase structure at elevated temperature. A Be-8 at. % Ni alloy exhibited 20% reduction in area in tensile tests at 1070°C (at which temperature the alloy is mostly beta). Unalloyed beryllium exhibited zero reduction in area at this temperature.

231. Protection against metal fatigue.

METAL INDUSTRY v. 99, p. 378-379, 10 Nov 1961.

Fatigue tests are conducted on sharply notched cylindrical specimens of 4340 steel, 17-7 PH stainless steel, 6061-T6 Al alloy and Cu-1.75% beryllium alloy using a rotating-beam machine at 3000 rpm. The effect of dodecyl alcohol on fatigue crack propagation of cleaned and uncleaned metal specimens is determined by cycling at nominal stress amplitudes of 11.5-1000 psi.

232. Rodigina, E. N. and Gomel'skii, K. Z.

Enthalpy of beryllium and lithium oxides at high temperatures. ZHURNAL FIZICHESKOI KHIMII

v. 35, p. 1828-1831. Aug 1961. (In Russian)

The enthalpy relative to 293.15°K was measured for lithium oxide in the range 373.20 to 1127.9°K and for beryllium oxide in the range 363.44 to 1127.9°K. Equations for the enthalpies are presented.

233. Samuels, L. E.
 Damaged surface layers: metals. In SURFACE
 CHEMISTRY OF METALS AND SEMICONDUCTORS.
 N. Y., Wiley, 1960. p. 82-106.

The nature of the physical altered layers of metal caused by cutting or polishing is reviewed, consideration being given to residual elastic stress, surface topography and accumulation of embedded abrasive in ... beryllium. Distinction is made between plastically deformed layers and amorphous-like Beilby layers.

234. Sawkill, J.
 DEFORMATION AND ANNEALING PROCESSES
 IN BERYLLIUM. Tube Investments Research
 Laboratories, Hinxton Hall, Cambridge, England.
 Oct 1961. 4p.

An analysis of the primary mode of fracture in beryllium, viz., basal cleavage, shows that the sequence of events leading to fracture is basal slip, the formation of bend planes, bend-plane splitting, and crack propagation. Nonuniform flow, due to constraints or inhomogeneities, is responsible for the formation of bend planes. As the temperature of deformation is increased in the range 0-400° C, the deformation becomes less inhomogeneous, the constraints less severe, and instead of showing sharp bend planes, the basal planes will bend continuously, giving higher ductility. On subsequent annealing the continuously bent grains will have a strong tendency to polygonize, with little grain refinement or change in texture. Polygonization can be avoided, and recrystallization induced, by annealing after large and homogeneous deformation. A precipitation heat treatment of hot-worked cast metal may allow large deformations to be achieved in the warm-working range. Subsequent annealing may result in substantial grain refinement and textural changes by recrystallization.

235.

Schmidt, R.

New developments improve ductility of beryllium.

METAL PROGRESS v. 81, no. 2, p. 78-82.

Feb 1962.

Ductile beryllium can be produced by zone refining to a low impurity level. High-strength beryllium wire with a tensile strength of 190,000 psi. has been developed. It may be useful for wrapped structures and for electrical applications.

236.

Shklyarevskii, I. N. and Yarovaya, R. G.

Optical properties of beryllium in the infrared

spectral region. OPTICS AND SPECTROSCOPY

v. 11, nos. 5-6, p. 355-357. Nov-Dec 1961.

The optical constants, Hall constant, and static conductivity of vacuum-deposited layers of beryllium were measured in the 0.8-11 μ region at 290 and 82°K. It was found that the properties of beryllium in the indicated spectral region are determined entirely by free current carriers. Using the formulas of the normal skin effect, and taking account of the quantum character of the interaction of free carriers with the infrared radiation, the concentration, effective mass, and frequency of collisions among carrier particles were determined. It was shown that the temperature dependence of the optical properties of beryllium is determined by the frequency of these collisions.

237.

Smirnov, M. V. and Chukreev, N. Ya.

The behavior of beryllium in salt melts in

contact with metallic beryllium. RUSSIAN

JOURNAL OF INORGANIC CHEMISTRY v. 4,

no. 11, p. 1168-1172. Nov 1959.

The reduction of divalent beryllium in salt melts by metallic beryllium has been followed by changes in the redox potential of the system (molybdenum electrode), which reaches values of 1.4 V. The equilibrium constant for the reaction $\text{Be}^{2+}_{(\text{melt})} + \text{Be} \rightleftharpoons 2\text{Be}^{+}_{(\text{melt})}$ in molten alkali metal chlorides has been measured at various

237. (cont'd)

temperatures. The relationship between the equilibrium constant and the temperature is given by the expression

$$\log K = \left(2.36 - \frac{4904}{T} \right) \pm 0.10.$$

The addition of fluoride ions to the melt displaces the equilibrium towards the formation of divalent beryllium.

238.

Smyth, H. T. and Merz, K. M.

AN INVESTIGATION OF THE THEORETICAL
AND PRACTICAL ASPECTS OF THE THERMAL
EXPANSION OF CERAMIC MATERIALS; QUAR-
TERLY PROGRESS REPORT. Cornell Aeronau-
tical Laboratory, Inc., Buffalo, New York.

Report CAL-PI-1273-M-7. 15 June 1960. 5p.

(Contract NOrd-18419) ASTIA AD-239 649.

Summaries are presented of activities in the development of a method for computing the field at the location of each ion, and experimental measurements of the thermal expansion coefficients of MgO-MgO. Al_2O_3 systems, and BeO-MgO systems.

239.

Stehsel, M. L., Hale, R. M. and Waller, C. E.

MODULUS OF RUPTURE MEASUREMENTS ON
BERYLLIUM OXIDE AT ELEVATED TEMPERA-
TURES. Aerojet-General Corp., Azusa, Calif.

Report AGC-1777. March 1960. 35p. (Contract

W-7405-Eng-48).

A bend-test furnace is described for measuring the modulus of rupture on beryllium oxide at elevated temperatures. Test beams were subjected to three-point loading by utilizing a conventional Instron tensile-testing machine. These tests were performed

239. (cont'd)

in a helium atmosphere at temperatures ranging from 75 to 3000° F. Comparative data are presented for hot-pressed, cold-pressed, and slip-cast specimens supplied by several manufacturers. Preliminary results indicated that, in general, the hot-pressed specimens have the highest modulus at all temperatures which were investigated.

240.

Stonehouse, A. J.

Beryllides for lightweight, high temperature structures. MATERIALS IN DESIGN ENGINEERING v. 55, no. 2, p. 84-86. Feb 1962.

Beryllides have an excellent combination of high temperature strength, oxidation resistance and low specific gravity.

241.

Thermocouples take high heat.

IRON AGE v. 188. p. 124. 14 Dec 1961.

Development of beryllium-oxide insulated elements of W-Re or W-W/Re with Ta sheaths for use at 4000° F. The beryllium oxide powder also provides resiliency that insures resistance to impact, vibration and pressure.

242.

Vachet, P. and Logerot, L. M.

MECHANICAL PROPERTIES OF EXTRUDED BERYLLIUM AT ELEVATED TEMPERATURES: THE INFLUENCE OF SOME NON-METALLIC ELEMENTS. Institute of Metals. Conference on Metallurgy of Beryllium, London, 1961. Preprint No. 57. 1961. 6p.

Among the non-metallic impurities found in beryllium, two have an important influence on its mechanical properties, viz. oxygen and carbon. Flake beryllium obtained by the electrolytic process contains ~0.3% beryllium oxide and 0.04% carbon, whereas

242. (cont'd)

the metal produced by reducing the fluoride with magnesium contains ~0.8% beryllium oxide and 0.04% carbon. A study was made of the possible effect on the mechanical properties at elevated temperature of large amounts of oxygen and carbon intentionally added to metal obtained by the electrolytic process. The influence of such addition of weldability was also examined. The tests were made on beryllium containing at to 3% oxide and 1% carbon. Short-time mechanical tests under increasing load, and tests of longer duration at constant load were performed between 400 and 800° C. It was observed that carbon sensibly increased the strength at elevated temperature, but that the ductility was lower. Consequently, the workability of the metal at high temperature was reduced and the weldability became poorer.

243.

Vickers, W.

COMPATIBILITY OF BERYLLIUM WITH VARIOUS

REACTOR MATERIALS. English Electric Co.,

Ltd., Atomic Power Division, Whetstone, Leicester,

England. Oct 1961. 5p.

The compatibility of beryllium with alumel, chromel, copper, mild steel, molybdenum, nickel, niobium, stainless steel, tantalum, titanium, thermoflex, uranium, zirconium, zirconium alloy (Zr - 1/2 Cu - 1/2 Mo), sintered alumina, sintered magnesia, sintered zirconia, powdered alumina, and powdered zirconia has been studied at 550 and/or 600°C. The tests were carried out in vacuum and/or carbon dioxide containing less than 10 ppm by weight of water. Attempts to retard the reaction with mild steel and/or stainless steel at 600°C have been made by coating the steels with chromium, alumina, zirconia, silicon carbide, tantalum carbide, tungsten carbide and a nitrogen-diffusion layer. Three annealing times up to 2000 hours have been used, and the extent of reaction and reaction equations have been determined where possible. A general discussion of the results is given.

244.

Wigotsky, V. W.

'Matched' materials and moving copper cond-

ductors improve gyro precision. DESIGN

NEWS v. 16, p. 12-13. 29 Sept 1961.

Selection of materials for uniform stress and thermal characteristics to increase the precision of a miniature floating gyro having long-term drift stability. Component materials include M50 toolsteel, 52100 steel, copper and beryllium. Thermal expansion coefficients of parts result in constant bearing preload.

245. Wilsdorf, H. G. and Wilhelm, F.
ON THE BEHAVIOR OF DISLOCATIONS IN
BERYLLIUM. Franklin Institute Laboratories,
Philadelphia, Penna. Oct 1961. 4p.

Dislocation patterns have been examined with the electron microscope, using diffraction contrast mechanism, in single-crystalline and polycrystalline beryllium specimens of commercial and Pechiney flake purity. The main results of the investigation are: (1) glide dislocations are strongly hindered in their movements and often pinned by small precipitates in beryllium of commercial purity; (2) dislocation tangles have been observed in deformed Pechiney flake beryllium; the presence of round as well as elongated prismatic dislocation loops is in evidence; (3) dislocations on different slip systems may react to form incipient networks; (4) in the Pechiney flake material, in which obstacles are comparatively rare, the dislocations have a pronounced tendency to align along the crystallographic directions, indicating a strong Peierls-Navarro force; (5) the dislocations were always immobile at the stress created by a high density have been found to lie in (1210).

MISCELLANEOUS

246. Action in beryllium.
IRON AGE, v. 199, no. 16, p. 107. 19 Oct 1961.

The capacity and operations of a beryllium fabrication plant which includes a precision machine shop and an inspection setup including x-ray. Review of the government stockpiling program and of foreign and domestic sources of beryllium ore.

247. Bowle, S. H. U. et al
Electronic instruments for detecting and assay-
ing beryllium ores. INSTITUTION OF MINING
AND METALLURGY. BULLETIN No. 641,
p. 345-359. 1960.

247. (cont'd)

Detection of beryllium-bearing minerals in the field and the subsequent mining of ore are made easier by the use of a portable electronic instrument, employing BF₃ counters, to measure the neutrons emitted when beryllium is bombarded by γ radiation of suitable energy. Similar equipment, for laboratory use, makes for accurate analyses of beryllium ores to be made without the need of costly and time-consuming chemical analyses.

248.

Bunshah, R. F.

A FRESH LOOK AT THE PROBLEMS OF BERYL-

LIUM. University of California, Livermore, Calif.

Oct 1961. 9p.

The current status of beryllium metallurgy is reviewed. The nonsystematic variation in the mechanical properties, particularly the low room-temperature properties and the ductility minimum around 600° C, are its most disturbing features. Recent work shows that the 600° C ductility minimum can be eliminated by overaging of controlled compositions, which means that commercial beryllium may be considered as a complex, unstable age-hardening alloy rather than as a somewhat impure dilute alloy. The implications of this as regards the room-temperature properties are discussed. Some comments on the technological problems and analytical requirements are made.

249.

Christopher, S. S.

Beryllium research and development. In U. S.

Air Force, Air Force Systems Command

Aeronautical Systems Division, Wright-

Patterson Air Force Base, Ohio. MATE-

RIALS SYMPOSIUM, 13-15 SEPTEMBER 1961.

PHOENIX, ARIZ. ASD Technical Report 61-322.

July 1961. p. 885-898.

Reviews problems of brittleness, joining, processes and wrought products, and structural integrity, as investigated in Air Force beryllium programs and as they affect research and development programs by other government agencies.

250. Cost-sharing contract for beryllium research;
Air Force contract with Brush Beryllium Co.
PRODUCT ENGINEERING v. 32, no. 36, p. 3-4.
4 Sept 1961.

Contract calls for production of beryllium sheets with better and more consistent bendability in three directions, improved surface finish and better uniformity of thickness and gage.

251. Dalgarno, A. and McNamee, J. M.
Calculation of polarizabilities and shielding
factors. JOURNAL OF CHEMICAL PHYSICS
v. 35, no. 10, p. 1517-1518. Oct 1961.

The dipole and quadrupole polarization of beryllium $\text{Be}(1s^2 2s^2)$ is calculated using the unperturbed Hartree-Fock 2s orbital $u^{(0)}(r | 2s)$ and the perturbed Hartree-Fock 2s orbital $u^{(1)}(r | 2s)$. The effects of the approximation in calculations of the dipole polarizability, the electric field strength at the nucleus, the quadrupole polarizability, and the nuclear shielding factor ν_∞ are tabulated.

252. McClung, R. W.
DEVELOPMENT OF NON-DESTRUCTIVE TESTING TECHNIQUES FOR THIN-WALL BERYLLIUM TUBING. Oak Ridge National Laboratory, Tenn.
Oct 1961. 6p.

This paper discusses briefly the need for testing of beryllium tubing and some of the problems that have been encountered during the development program. Mention is made of typical discontinuities which are detected. Low-voltage radiography is presented as one of the most useful techniques. Extensive efforts, including helium

252. (cont'd)

atmospheres and dark-room, bare-film exposure techniques, were necessary to achieve this state of efficiency on material with such a low-radiation absorption coefficient. The problems encountered because of the very high velocity of ultrasound in beryllium are described. The solutions to these problems and the accomplishments using both resonance and pulse-reflection techniques are presented. The present state of usefulness of the encircling-coil eddy-current technique is discussed. Other more standard techniques included are liquid-penetrant inspection, pneumatic gaging, and mass-spectrometer helium-leak tests. Comparison is made of these various testing methods on the basis of cost and capabilities.

253. Materials selector issue; non-ferrous metals;
tables. MATERIALS IN DESIGN ENGINEER-
ING v. 54, no. 5, p. 146. Mid-Oct 1961.

Tables.

254. Metal selector, 1961; beryllium-bearing alloys.
STEEL v. 149, no. 16, Sup S23-24. 16 Oct 1961.

Table.

255. Metallurgy of beryllium.
METAL INDUSTRY, v. 99, p. 437-439. 1 Dec 1961.

Review of papers presented at the First International Conference on Beryllium organized by the Institute of Metals. Topics include mechanical and physical properties, corrosion resistance, preparation and fabrication techniques, diagnostic techniques, applications in reactors and aircraft and future trends.

256. Mining and metallurgy at Lake Bernic-Chemalloy
mines them medium rare. CANADIAN CHEMICAL
PROCESSING v. 45, p. 78-80. Oct 1961.

Analysis of Canadian pegmatite ores indicate 20% Cs, 2% lithium oxide, 0.2% beryllium oxide, 0.32% tantalite and 0.05% Ga. Chemical and physical properties of Cs, Li and Be are given which permit applications in the electronic, thermoelectric, nuclear, missile and rocket fields.

257. Mironov, N. and Kostogarov, S.
Beryllium - current status of technology and
investigations. SOVIET JOURNAL OF ATOMIC
ENERGY v. 9, no. 4 p. 875-878. Sept 1961.
A review. Current status of technology and investigations. 13 references.

258. National Metallurgical Laboratory. (India)
Council of Scientific and Industrial Research,
Jamshedpur. SYMPOSIUM ON LIGHT METAL
INDUSTRY IN INDIA, PROCEEDINGS. 14-17
Feb 1961. 23p.

Abstracts of papers presented on reduction and refining, fabrication, micro-structure and transformations, analysis techniques and industrial application of beryllium...and its alloys.

259. Perelygin, V.P., Myachkova, S.A. and Tolstov, K.D.
Introduction of grains of beryllium into photo
emulsions. PRIBORY I TEKHNIKA EKSPERIMENTA
v. 6, no. 4, p. 145-147. 1961 (In Russian)
260. Perelygin, V.P., Myachkova, S.A. and Tolstov, K.D.
Loading of photographic emulsion with beryl-
lium grains. INSTRUMENTS AND EXPERIMENTAL
TECHNIQUES. No. 4, p. 770-771. July-Aug 1961.

261. Petch, M. J.
Metallurgy of beryllium. NATURE v. 192,
p. 1137-1139. 23 Dec 1961.

Summary of the pertinent points of 70 previous papers on the present status of knowledge of the metallurgy of beryllium, and of its application to aerospace-vehicle and atomic-reactor construction. Various problems involved in the use of beryllium are noted, with particular attention to the brittleness of the metal.

262. Recent design data on beryllium.
ENGINEERING MATERIALS AND DESIGN v. 5,
no. 1, p. 28-29. Jan 1962.

263. Silina, G. F., Zarembo, Yu. I. and Bertina, L. E.
BERYLLIUM-CHEMICAL TECHNOLOGY AND
METALLURGY. Moscow, Atomizdat, 1960. 120p.
(In Russian)

264. The year in light metals: beryllium
LIGHT METAL AGE v. 19, nos. 11-12, p. 9,
12, 23. Dec 1961.

Beryllides, atomic energy, inertial guidance systems, wire drawing, research and development, gears, fabrication, capacity, usage, price, ore, foreign, and toxicity are the subheadings for the contents of this review article.

AUTHOR INDEX

Abramova, V. G.	14
Adamovich, L. P.	1, 10
Agarwal, R. P.	39
Aidarkin, B. C.	11
Aleksandrovich, K. V.	13
Alexander, W. K.	196
Allen, B.	197
Antill, J. E.	83
Appala Raju, N.	12
Arndt, E. J.	190
Austerman, S. B.	24, 148, 198, 199
Bagaryatskii, Yu. A.	8
Barber, A. H.	34
Beaver, W. W.	2, 85, 163
Belyaev, A. I.	176
Bennett, E. W.	46
Bennett, S. L.	149
Bennett, W. D.	35
Bennett, W. D. G.	200

Berezin, I. A.	13
Bertina, L. E.	263
Beus, A. A.	130, 131
Bhattacharya, A. K.	40
Biermann, W. J.	149
Blanco, R. E.	150
Bleshinskii, S. V.	14
Booker, J.	201
Bort, C. I.	169
Bosik, I. I.	41, 42
Botje, J. M.	119
Bowers, J. E.	88
Bowle, S. H. U.	247
Bradshaw, W. G.	76
Brayman, J.	87
Brock, P.	88
Bruin, H. J. de	43, 170, 171, 172
Budnikov, P. P.	173
Bugel'skii, Yu. Yu.	132
Bunce, J. E. J.	202
Bunshah, R. F.	248
Canal, J. R.	104
Chang, R.	203

Chistyakov, N. E.	143
Christopher, S. S.	249
Chukreev, N. Ya.	237
Cieslicki, M. E.	89
Coons, W. C.	151
Cotterill, P.	15
Craik, R. L.	105
Crossley, F. A.	204
Dalgarno, A.	251
Davies, M. W.	81
Denham, A. H.	133
Denny, J. P.	90, 100, 101
Derham, L. J.	174
Dolezal, J.	28
Donaldson, H. M.	18
Doyle, W. P.	205
Dressel, W. M.	16
Eaton, N. F.	91
Edwards, K. L.	175
Eichelberger, J. F.	206
Ellis, G. C.	121, 225
Ells, C. E.	207
Eremenko, V. N.	208

Evans, R. E.	202
Evans, W.	207
Eyre, P. B.	93, 94
Farthing, T. W.	94
Feith, A. D.	95
Firsanova, L. A.	3, 176
Fischer, R. B.	160
Fisher, J. G.	123
Florence, T. M.	172
Forbes, B. G.	134, 135
Ford, R. A.	120
Franzen, J.	17
Freeman, D. B.	180
Fuchs, F. O.	4, 5
Fugardi, J.	96
Funck, E.	44
Galinos, A. G.	62
Ganapolsky, V. I.	45
Garber, R. I.	209, 210
Gasc, C.	211
Gavrilova, A. V.	8
Gavrilova, N. D.	66
Gavrilyuk, N. D.	67

Gaylord, E. W.	212
Gelles, S. H.	213
General Electric Co., Flight Propulsion Laboratory Dept. Cincinnati Ohio. .	214, 215
Giemza, C. J.	216
Gilkey, M. M.	136
Gindin, I. A.	209, 210
Goforth, R. E.	120
Gomel'skii, K. Z.	232
Goosey, R. E.	15
Gough, A. R. S.	46
Gowen, E.	194
Graham, L. G.	203
Greetham, G.	177
Grigor'ev, A. I.	47, 48
Grishin, I. A.	19
Guest, J. C.	97, 217
Gurevich, V. M.	49, 50
Hale, R. M.	239
Hamner, R. L.	51
Hanna, G. L.	78
Harris, L. A.	51
Hausner, H. H.	218
Havens, R.	137

Hayes, A. F.	98
Hebeler, H. K.	99
Herman, M.	190, 219
Hess, W. T.	124
Hessinger, P. S.	152
Hessler, B. H.	100, 101
Hiern, M. N.	138
Higgins, J. K.	83
Hill, N. A.	109, 178, 220
Hindle, E. D.	6
Hintenberger, H.	17
Hiser, R. A.	18
Hodge, E. S.	112
Hoffman, W.	31
Hollis, W. S.	221
Hooper, E. W.	179
Hopkins, A. R.	148
Hudson, M. J.	217
Hughel, T. J.	222
Hunt, E. C.	139
Hyde, K. R.	52
Inouye, H.	84
Isupova, E. N.	53, 54

Jenkins, H. A. H.	180
Jones, J. W. S.	161
Jordan, C. B.	7
Julien, H. P.	103
Kairaitis, D.	171
Keeley, R. L.	168
Keen, N. J.	179
Keler, E. K.	53, 54
Khandamirova, N. E.	55
Khubchandani, P. H.	153
Kluiber, R. W.	56
Kolenkova, M. A.	45
Koptsik, V. A.	66, 67
Korenman, I. M.	19
Korringa, J.	36
Kostogarov, S.	257
Kothari, L. S.	153
Kravchenko, T. U.	10
Krypyakevich, P. I.	57, 58
Kunkler, W. C., Jr.	104
Kyffin, P. D.	105
Lampson, F. K.	223
Lannan, P. E.	154

Leszynsk, W.	162
Levine, E. D.	230
Levinson, A. A.	140
Levy, D. J.	79, 194
Lewis, J. W.	56
Limpany, B. B.	163
Lindsay, H. M.	20
Liner, A. I.	45
Livey, D. T.	111, 165
Lockheed Aircraft Corp., Missiles and Space Division, Sunnyvale, Calif.	224
Logerot, L. M.	242
Longstaff, D. A.	91
Maak, F.	80
McClelland, J. D.	106, 107
McClung, R. W.	252
McDuffie, H. F.	182
Mackay, K. J.	21
Mackenzie, J. E.	59
McNamee, J. M.	251
Maekawa, S.	22
Malhomme, P.	125
Malik, W. U.	60, 61
Marcellin, W. J.	126
Martin, A. J.	15, 175, 177, 225

Mathis, D. L.	27
Matsuo, S.	141
Mayer, L. W.	108
Mazurenko, E. A.	23
Meckenstock, K. U.	31
Mehrota, R. C.	39
Mel'nikova, T. A.	29
Meredith, J. E.	226
Merz, K. M.	238
Meyer, R. A.	24, 199
Michal, J.	28
Miliotis, J. A.	62
Minné, R.	63
Mirand, P.	157
Mironov, N.	257
Missel, L.	181
Moore, A.	20, 169, 197, 227
Moore, R. E.	182
Morozumi, S.	37
Munro, W.	109
Murray, P.	165
Myachkova, S. A.	259, 260
Naidich, Y. V.	208

Nakatani, H.	110
National Metallurgical Laboratory (India). Council of Scientific and Industrial Research, Jamshedpur	258
Neelakantum, K.	12
Nekrasov, I. Ya.	142
Nichkov, I. F.	183
Nishigaki, S.	155, 156
Nissen, W. I.	137
Nizhenko, V. I.	208
Novoselova, A. V.	41, 42, 48, 71, 72, 73
Nowak, W. B.	230
Nuclear Metals, Inc., Concord, Mass.	229
O'Boyle, D.	184
Obukhov-Denisov, V. V.	64
O'Connor, D. J.	52
Olds, G. C.	167
O'Neill, J. S.	111
Paine, R. M.	201
Paprocki, S. J.	112
Paris, R.	185
Pemsler, J. P.	186
Perelygin, V. P.	259, 260
Perkins, G. D.	187
Perlmutter, I.	38

Perrin, J. S.	112
Petch, N. J.	261
Phennah, P. J.	81
Pickett, J. J.	230
Plaksin, I. N.	188
Plotnikova, R. N.	26
Podgornova, V. S.	69
Randall, R. N.	114
Rao, G. S.	40
Reeves, G. L.	168
Ritchey, R. A.	16
Robinson, J. A.	91
Rochow, E. G.	63
Rodigina, E. N.	232
Rosenbaum, J. B.	137
Rubenstein, H. S.	90
Rundkvist, D. V.	143
Samuels, L. E.	233
Saulnier, A.	157
Savitskil, E. M.	57
Sawkill, J.	21, 25, 226, 234
Schilling, J. H.	144
Schmidt, R.	235

Schwarzenberger, D. R.	21, 25
Schweisheimer, W.	145
Schwenzfeler, C. W.	18
Scott, V. D.	20
Secrest, V. S.	117
Semenenko, K. N.	47, 71, 72, 73
Sen Gupta, A. K.	65
Shaffer, J. H.	182
Sharples, J. T.	189
Shcherbov, D. P.	26
Sheinhartz, I.	96, 115
Sherwood, E. M.	116, 117
Shiroyanagi, I.	37
Shklyarevsky, I. N.	236
Shu, H.	212
Shubin, U. V.	209, 210
Silina, G. F.	263
Silver, J. M.	122
Slattery, G. F.	6
Smirnov, M. V.	183, 237
Smith, D. D.	88
Smith, R.	82
Smith, W. M.	106

Smyth, H. T.	238
Solnyshkin, V. I.	188
Sorensen, H.	146
Spangler, G. E.	190, 191, 219
Stanton, R. E.	139
Stehsel, M. L.	239
Stonehouse, A. J.	201, 240
Straumanis, M. E.	27
Strukov, B. A.	66, 67, 68
Sulcek, Z.	28
Sumner, G.	200
Suvorovskaya, N. A.	29
Suzuki, S.	141
Swarthout, D. G.	24, 199
Taketatsu, T.	30
Talipov, S. T.	69
Tananaev, I. V.	70
Tatman, M. E.	118, 192
Temple, R. B.	43, 170, 171
Terry, C. A.	94
Theodore, J. G.	163
Thomas, P. R.	103
Thome, P.	125

Tolstov, K. D.	259, 260
Tsangaris, J. M.	62
Turova, N. Ya.	71, 72, 73
Tyapkin, Yu. D.	8
Tylkina, M. A.	57
Udalova, V. V.	74
Umland, F.	31
United Kingdom Atomic Energy Authority. Engineering Group, Windscale, Cumberland, England	32
United Kingdom Atomic Energy Authority. Production Group, Windscale, Sellafield, England	32
United Kingdom Atomic Energy Authority, London, England	9
Urie, J. G.	147
Vachet, P.	242
Van Houten, G. R.	119
Van Thyne, R. J.	204
Venkatasubramanian, K.	75
Vickers, W.	128, 243
Vil'komirskii, I. E.	193
Vinogradova, A. D.	70
Vorob'eva, O. I.	41, 42
Voskresenskaya, M. N.	29
Walt, E.	52
Wallace, C. G.	33

Waller, C. E.	239
Webb, J. S.	133
Wells, R. A.	139
Werner, W. J.	84
Westlund, E. F.	129
Whitby, L.	194
White, J. F.	119
Wigotsky, V. W.	244
Wilhelm, F.	245
Willardson, R. K.	187
Williams, J.	161
Wilsdorf, H. G.	245
Windecker, C. E.	158
Wood, W. W.	120
Woodfine, B. C.	81
Wright, D. B.	121
Wright, E. S.	76
Wright, W. J.	122
Yanagisawa, M.	141
Yarovava, R. G.	236
Yoblin, J. A.	98
Yoneyama, Y.	22
Yutsis, B. V.	1

Zarembo, Yu. I.	263
Zehms, E. H.	107
Zeppelin, H. von	195
Zheludev, I. S.	49, 50
Zinina, G. N.	69
Zvyagil'skii, A. A.	173